FINAL

DOE/EA-0102

ENVIRONMENTAL ASSESSMENT

STEAM GENERATOR TUBE INTEGRITY PROGRAM

SURRY STEAM GENERATOR PROJECT

Hanford Site
Richland, Benton County, Washington

March, 1980

U.S. DEPARTMENT OF ENERGY

Assistant Secretary for Environment

WASHINGTON, D.C. 20585

CONTENTS

1. DESCRIPTION OF THE PROPOSED ACTION

The U.S. Nuclear Regulatory Commission (NRC) has placed a Nuclear Regulatory Research Order with the Richland Operations Office of the U.S. Department of Energy (DOE) for expanded investigations at the DOE Pacific Northwest Laboratory (PNL) related to defective pressurized water reactor (PWR) steam generator tubing. This program, the Steam Generator Tube Integrity (SGTI) program, is sponsored by the Metallurgy and Materials Research Branch of the NRC Division of Reactor Safety Research. This research and testing program includes an additional task requiring extensive investigation of a degraded, out-of-service steam generator from a commercial nuclear power plant.

This comprehensive testing program on an out-of-service generator will provide NRC with timely and valuable information related to pressurized water reactor primary system integrity and degradation with time. This information has previously been unobtainable due to a lack of adequate research tools, particularly because of an inability to obtain an out-of-service specimen. The availability of the Surry II, Series 51, steam generator presents a unique opportunity for validating nondestructive testing techniques in a prototypic environment with an opportunity for visual corroboration. Information gained in the testing program will be used to upgrade NRC Regulatory Guides 1.121 and 1.83. Regulatory Guide 1.121, entitled "Bases for Plugging Degraded PWR Steam Generator Tubes," describes an acceptable method for establishing plugging criteria for defective PWR steam generator tubing. Regulatory Guide 1.83, entitled "Inservice Inspection of Pressurized Water Reactor Steam Generator Tubes," describes an acceptable method for establishing a program for in-service inspection. The generator would also provide a research vehicle for development and testing of improved methods of nondestructive testing, cleaning and decontamination.

The steam generator selected for this study was removed from Surry Power Station Unit II on May 5, 1979. A portion of the generator weighing 220 tons (2.0×10^5 kg) is proposed to be transported to Hanford (see Figure 1).

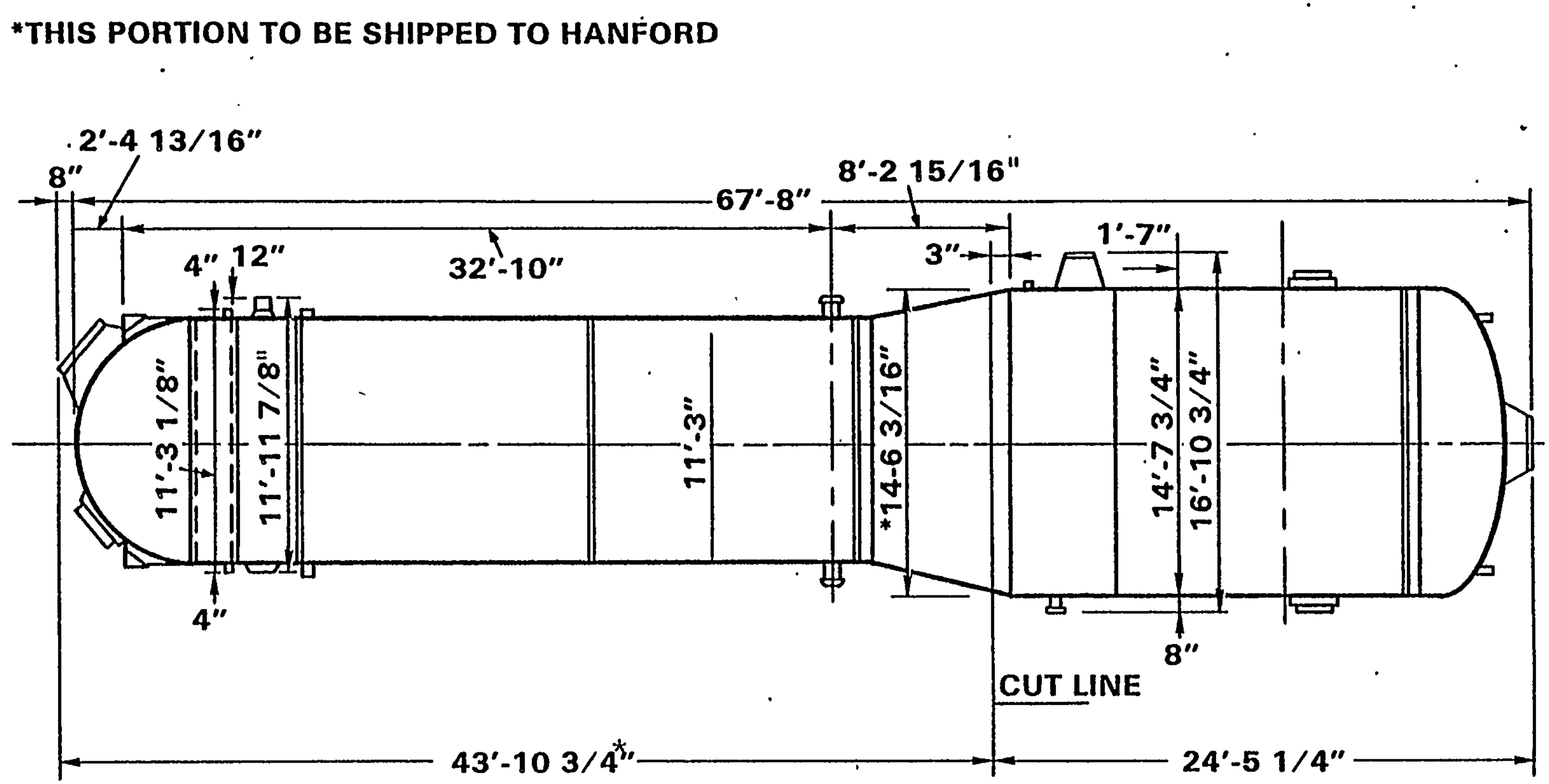


FIGURE 1. Steam Generator Detail

The proposed action involves the following sequential steps:

- Remove the steam generator from storage at the Surry Station.
- Transport to loading dock on James River.
- Load the generator on a sea-going barge.
- Transport the generator by barge to the Port of Benton at Richland, Washington.
- Unload and transport the generator overland to the 300 Area of the Hanford Site.
- Place the generator in interim storage until the temporary Steam Generator Examination Facility (SGEF) is completed.
- Begin construction of the temporary SGEF.
- Once the SGEF is complete, transport from interim storage and place the steam generator in the high-bay examination area.
- Begin the operational phase of the SGEF.
- After completion of the project, begin decontamination of the SGEF and dispose of the steam generator as waste.

The steam generator proposed to be shipped to Richland is now stored in an engineered storage facility at the Surry Station. The external surfaces of the generator have been decontaminated, and all openings have been sealed. Details of the contamination status and surface dose rates are contained in the Operational Plan for the project.[1]

A one-time-only exemption request has been submitted to the Department of Transportation (DOT) to ship the steam generator as a radioactive, Low Specific Activity package. The exemption request is attached in Appendix B. The shipment will not be made unless exemption is approved by DOT.

The steam generator will be removed from the storage vault at Surry and transported by a 104-wheel semitrailer to a loading dock located on the James River at the Surry site. Once the generator is loaded on an ocean-going barge, the loaded barge will be routed down the James River to the Atlantic Ocean. The proposed routing is then to the Panama Canal via the Windward Passage, as shown in Figure 2. Once through the Panama Canal, the barge will proceed northward to the Columbia River and upriver to the

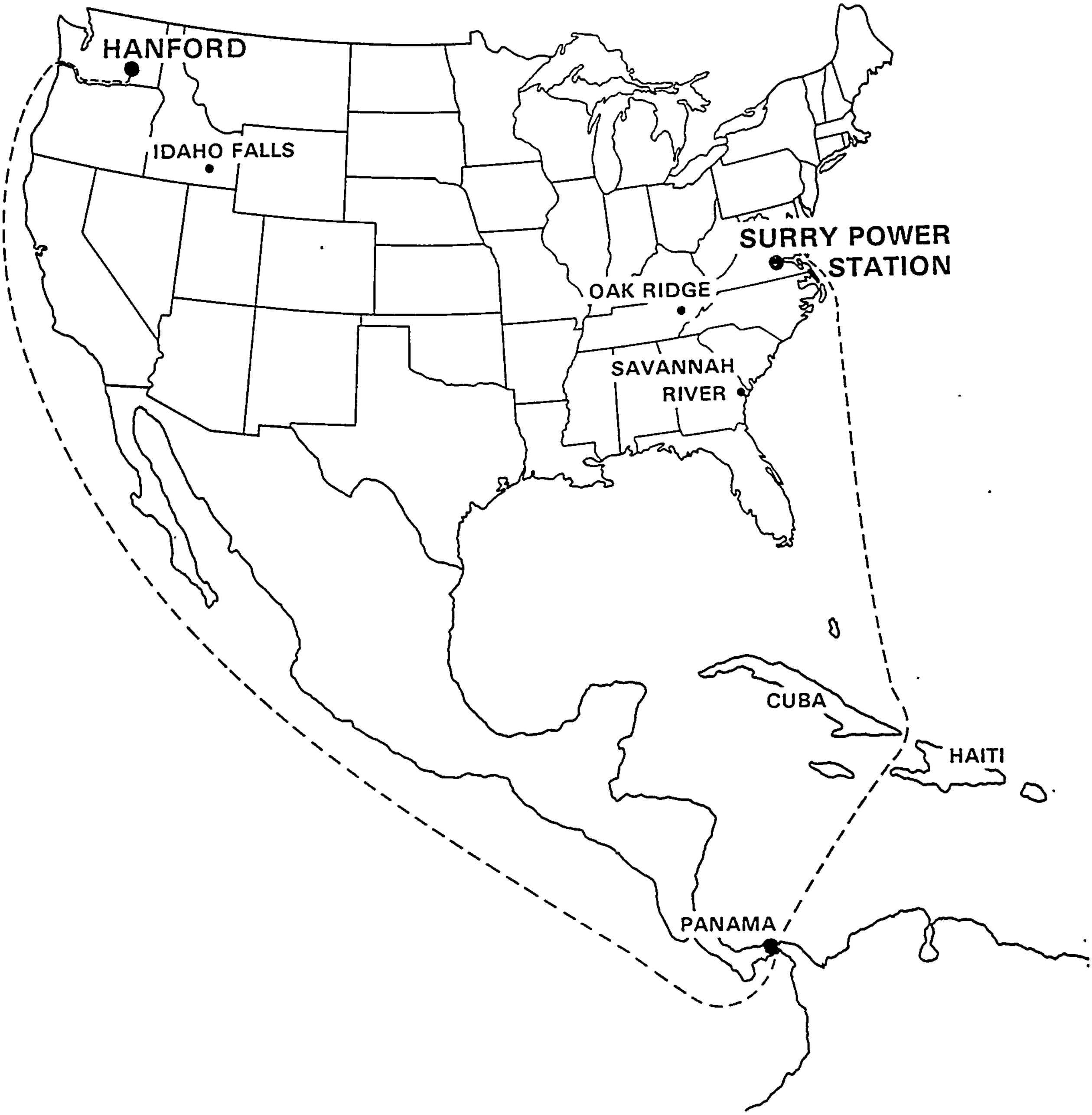


FIGURE 2. Proposed Transportation Route

Port of Benton at Richland, Washington, where it will be transported to the 300 Area by special truck/trailer. Table I compares reference landmarks and approximate miles offshore along the route.

At the Port of Benton, the generator will be unloaded and transported overland to the eastern portion of the 300 Area, where an interim storage location will have previously been prepared. Travel distance to the Hanford Site is 0.25 miles (0.4 km) with the interim storage location approximately 2 road miles (3.2 km) from the Port of Benton. This location is within a normally unoccupied, fenced security area. The interim storage location will consist of a concrete pad as shown in Figure 3. If early nondestructive testing becomes desirable, a suitably designed High Efficiency Particulate Air (HEPA)-filtered "greenhouse" will be constructed around the water-box man-way for positioning of remote In-Service-Inspection type apparatus. No cutting, welding or burning operations will be conducted during interim storage. Any opening of man-ways and inspection ports will be restricted to suitably "greenhoused" areas.

The proposed action to transport the generator to Hanford prior to completion of the SGEF is based on a feasibility study,[(2)] discussions with NRC, and interactions with DOE Richland Operations Office. First, Surry II generators will be positioned behind Surry I generators in the storage vault after the scheduled replacement of the Surry I generators. This positioning would eliminate access for removal of a Surry II generator. The proposal for early transport also presents an opportunity for limited nondestructive testing of the generator while in interim storage. Virginia Electric and Power Company (VEPCO) will not allow research activities on the Surry site because of additional radiation exposure accrual and liability under their site license.

The final phase of the proposed action is the construction and operation of a temporary building designated the Steam Generator Examination Facility (SGEF) at the DOE Hanford Site.[(3)] The SGEF will consist of a 1156-ft^2 (107.4-m^2) structure, 71-ft (21.6-m) high (including a basement), which will house the steam generator (see Figure 4). Attached to this structure will be a 952-ft^2 (88.4-m^2) structure housing change rooms and a load-out bay.

The SGEF will contain no office space. Personnel working in the facility will spend, on the average, less than 8 hr. per working day in the facility. The maximum work force in the facility is expected to be 10 people. The facility will house the following areas:

- highbay housing steam generator
- liquid waste tanks
- change rooms
- truck load in/out bay
- heating, ventilation, air conditioning and mechanical equipment.

TABLE I. Reference Points Along Proposed Shipping Route

Route Coordinates	Offshore Approx. Mi.	Landmarks
37°N - 75.5°W	42	East of Norfolk, Virginia
35.5°N - 74.5°W	50	East of C. Hatteras, North Carolina
33°N - 80°W	355	East of Charleston, South Carolina
26° - 80.5°W	350	East of Miami, Florida
21°N - 74.5°W	40	West of Great Inagua Island
20°N - 74°W	15	East of Cuba (Windward Passage)
18.5°N - 75°W	21	West of Haiti
18°N - 75.5°W	52	East of Jamaica
	Open Water to Cristobal, Panama	
7°N - 81°W	20	Azuero, Panama
17°N - 100°W	20	Acapulco, Mexico
23°N - 110°W	20	Cape Falso, Mexico (Baja California)
33°N - 119.5°W	155	West of San Diego, California
37°N - 122.5°W	20	West of San Francisco, California
43°N - 125°W	20	West of Cape Blanco, Oregon
42.3°N - 124°W	--	Entry to Columbia River

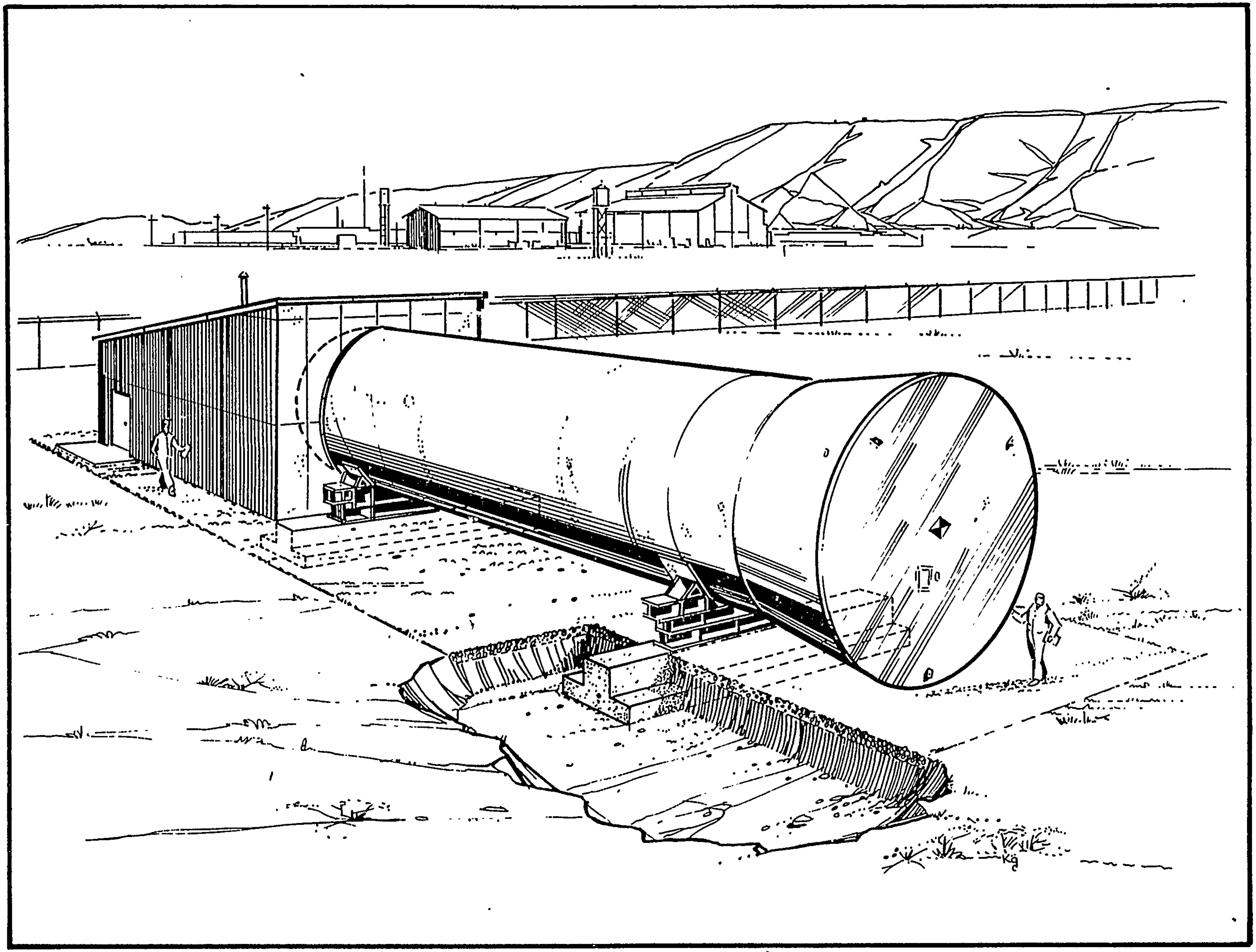


FIGURE 3. Interim Storage Facility for Steam Generator

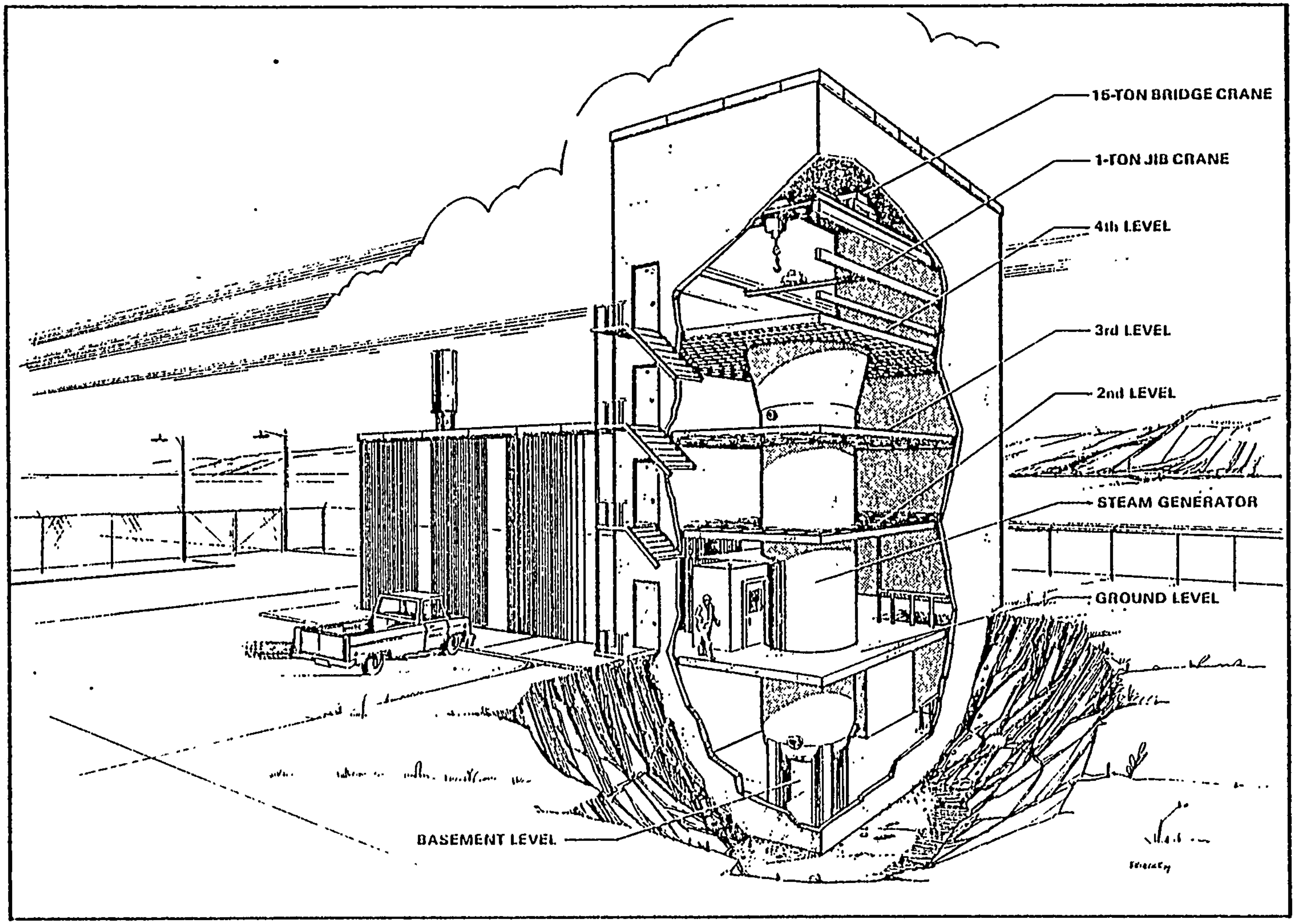


FIGURE 4. Steam Generator Examination Facility

The purpose of the Steam Generator Examination Facility is to provide a facility to conduct extensive nondestructive testing and destructive analysis on a steam generator retired from service after a small fraction of its intended service life. Conditions leading to removal from service are similar to problems being experienced in many other operating units. The choice of a Surry II generator was based on its early availability, the extent of damage, and the presence of a variety of identified corrosion defects. Research objectives can be broadly stated as 1) providing assurance that generator degradation has been adequately monitored through current regulatory procedures, and 2) identifying the degradation mechanisms sufficiently to help forestall premature or unexpected failure in other units.

2. DESCRIPTION OF THE RESEARCH PROGRAM

The initial research activity is proposed to be a comprehensive nondestructive examination (NDE) of the generator. Several NDE methods and equipment designs will be used, including experimental and developmental techniques or devices, to create a map of the defects in the generator. Based on statistical analysis of the defect map, the generator will be opened and specimens removed for further examination and testing. The destructive assay of specimens will allow confirmation of NDE results, while also providing needed input to NRC on the validity of new NDE approaches allowing appropriate licensing action. Removed tube specimens will also be tested for remaining serviceability as a function of actual degradation and NDE-indicated degradation. Typical tests would include burst and collapse pressures and leak-rate analysis. These tests will provide confirmation of mathematical models relating remaining tube strength to type and extent of defect. The models are based on previous tests conducted using mechanically (machined) and chemically placed defects simulating in-service degradation. Correlation of NDE-indicated degradation with actual remaining physical properties will allow evaluation of current NRC tube-plugging requirements. Unconservative plugging criteria could result in excessive generator leakage during certain postulated reactor transients. However, overly conservative tube plugging criteria would reduce reactor availability (power generation) and increase exposure of maintenance crews.

Destructive examination and sectioning of the generator will provide opportunity for visual confirmation that all damage in the generator is indeed being seen with current nondestructive examinations. A statistical evaluation will also result in indicating types and locations of defects as well as types and locations of secondary (steam) side deposits of corrosion products. Evaluation of secondary side deposits will provide information on operating and upset water chemistry effects on corrosion. It is anticipated that the research and testing program will result in valuable information for improvement of steam generator design.

Another proposed research avenue concerns decontamination and cleaning of steam generators. More restrictive radiation exposure limits coupled with increasing radiation in older plants will require efforts to reduce plant radioactivity. The NRC will be required to license proposed cleaning/decontamination schemes. Evaluation of proposed schemes must take into account not only radiation reduction effectiveness but long-term as well as short-term effects of the cleaning/decontamination process. For example, chemical concentration may occur in crevices, contributing to future corrosion damage. Proposed research would use specimens of the generator to evaluate decontamination/cleaning processes. Further, a suitable subsection of the generator could be employed for long-term viability testing, after decontamination, under simulated operating conditions.

A final currently identified proposed research avenue is materials recovery. Many thousands of tons of increasingly valuable resources are incorporated into massive nuclear power plant components. Reclamation of certain alloy components could provide large benefits in resource conservation. Research into this area would include decontamination methodology and material recovery in a form suitable for reuse.

The interim storage facility and the SGEF are proposed to be located in the 300 Area, which is part of the 570-square-mile (1476-km^2) government-owned and closely controlled Hanford Site in the southeastern portion of Washington State (See Figure 5). The 300 Area, which is 7 miles (11.3 km) north of the Richland City Center and 1 mile (1.6 km) north of the city limit, is located in the southeastern portion of the Hanford Site. It is

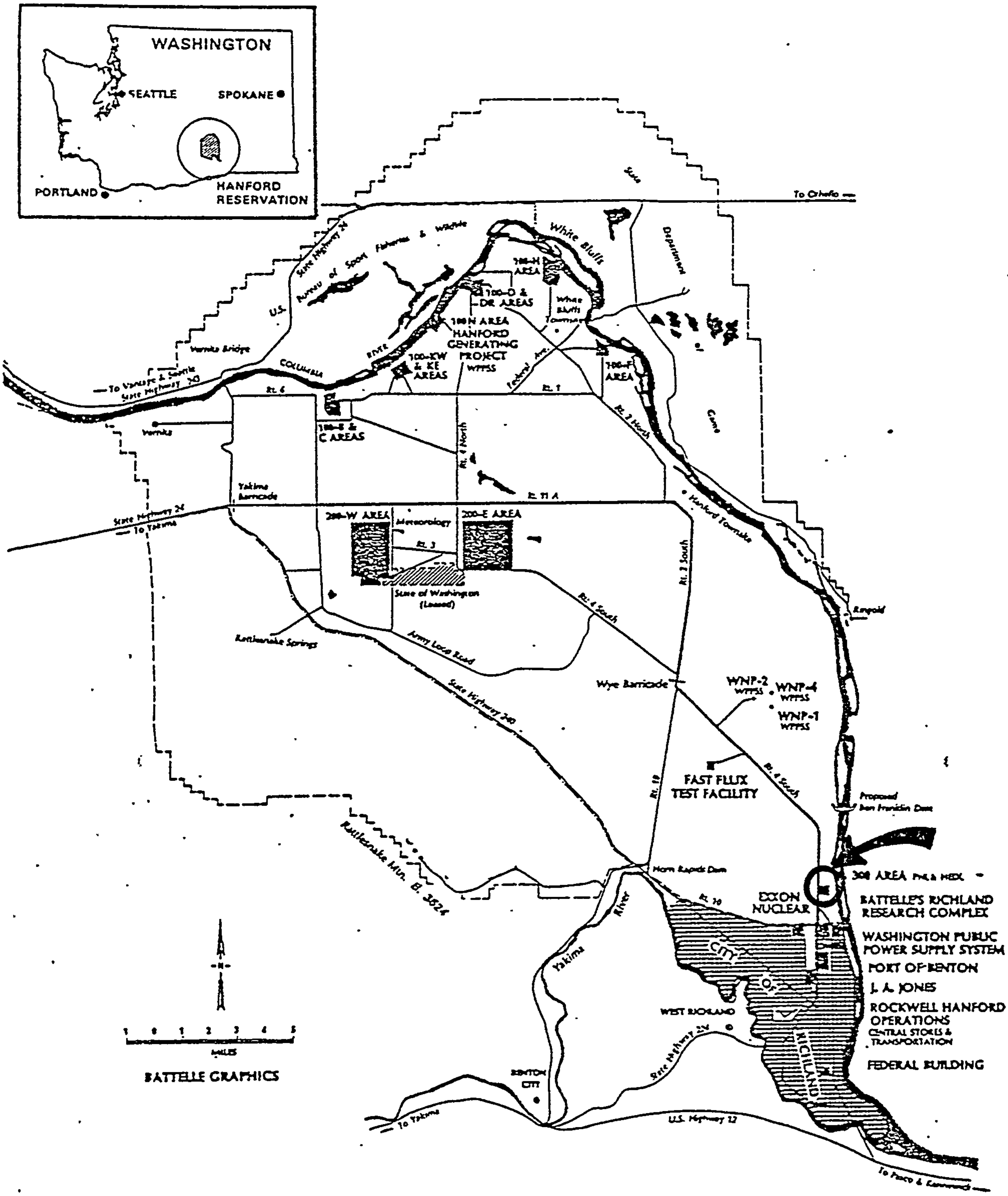


FIGURE 5. Location of the Hanford Site and 300 Area

planned that the SGEF will be located in the western half of the 300 Area, approximately 20 ft (6.1 m) east of the existing western perimeter fence and northwest of the 314 Building, and that the interim storage location will be in the northeastern quadrant of the 300 Area, just north of the sanitary waste trenches (see Figure 6).

Placing the SGEF in this location permits coordination with other similar research and development projects conducted in other 300 Area buildings, specifically the 314 Building, which contains office space for personnel working on the project. The interim storage location provides for adequate security during storage and minimum transport distance to the SGEF. In addition, the 300 Area location has the advantage of access to existing electrical, water and sewer without significantly burdening those utilities.

3. DESCRIPTION OF THE EXISTING ENVIRONMENT

The existing environment at the Surry Station is described in the Environmental Impact Appraisal and Final Safety Report (NRC Docket 50-280 and 50-281) for all activities associated with handling, removal and storage of the generators from Surry Units I and II. The environmental impacts of transportation as analyzed in NUREG-0170 are applicable to this transshipment.[4] Therefore, except for specific accident scenarios, the analysis in NUREG-0170 will be relied upon here to describe the existing environment.

The proposed interim storage location and SGEF construction site on the Hanford Site, specifically the 375-acre (151.8-hectare) 300 Area, is bounded on the east by the Columbia River and on the west by Hanford Route 4. Access to the 300 Area is strictly controlled for national security, safety, and health reasons. The predominant activities of the approximately 3000 people who work in the 300 Area are reactor fuel fabrication and research and development.

Current emissions from the 300 Area include:

- particulate emissions from an oil- and coal-fired power house equipped with a baghouse filter system;

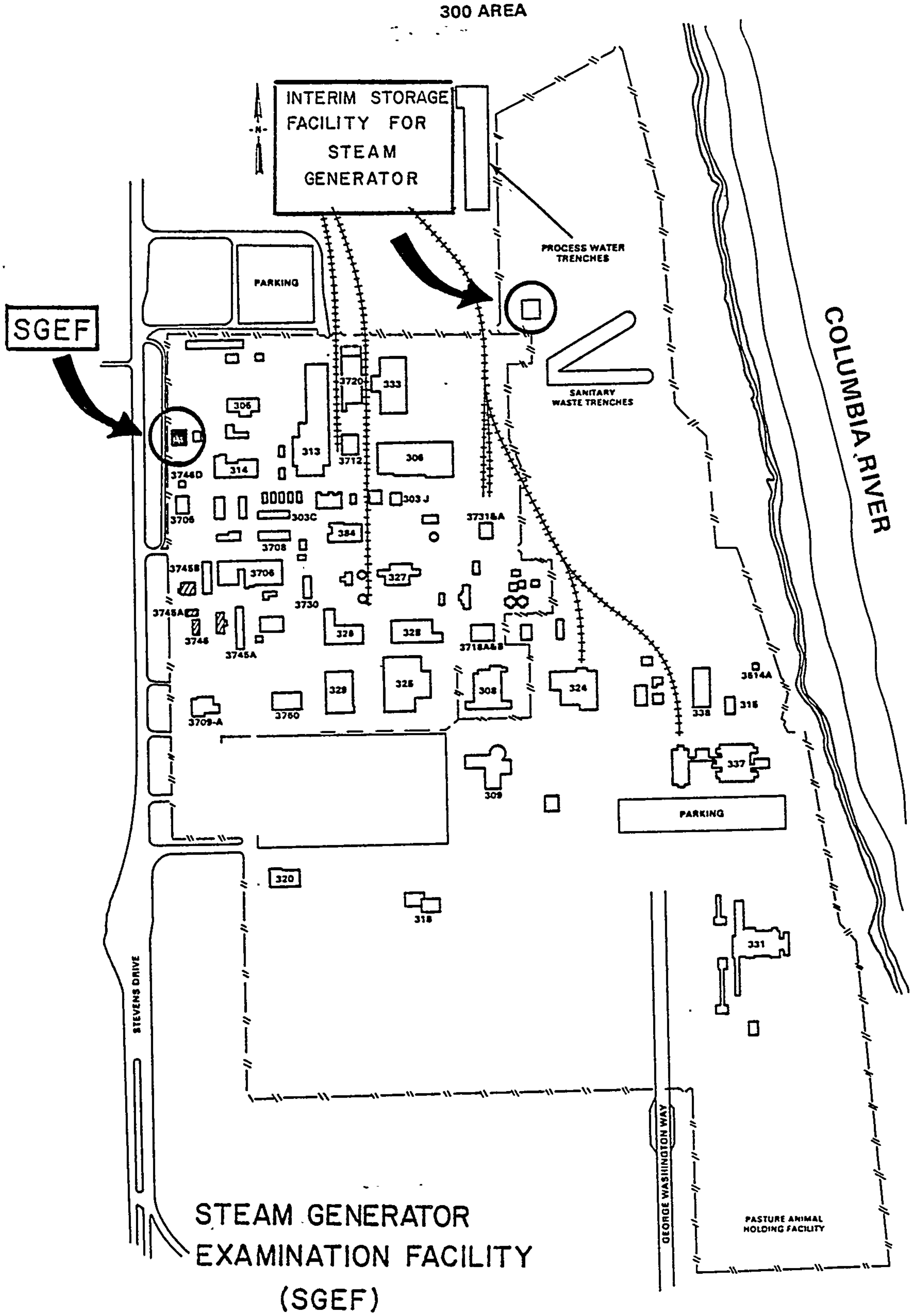


FIGURE 6. 300 Area Site Map

- intermittent oxides of nitrogen and flouride releases from a fuels manufacturing facility that utilizes nitric acid and hydrogen fluoride solutions;
- intermittent steam and particulate releases from several non-radioactive pathological and paper incinerators;
- sodium oxides from sodium processes including an elemental sodium-burning facility; and
- numerous other nonpolluting releases from roof vents, building stacks, and air conditioners.

The use of 99.97%-efficient (0.3-micrometer-diameter particles) single-, double-, or triple-stage HEPA filters in all radioactive ventilation systems reduces the release of radioactive particulates via 300 Area stacks to well below the ERDA Manual Chapter 0524, Annex A, Table II concentration guides.

The 300 Area treatment systems that receive liquid wastes include:

- a 2.5-million-gallon-(9463-m^3) per-day process water discharge that is dispensed into one of two 1500- by 10-ft (451- by 3-m) trenches located just north of the 300 Area;
- a sanitary waste system that discharges an average of 350,000 gallons (1250 m^3) per day to concrete septic tanks after which waste is chlorinated and discharged to one of two 600- by 10-ft (183- by 3-m) trenches;
- an intermittent filter backwash resulting from the potable water filter backwash that is discharged to the old south process pond; and
- 1450 gallons (5.5 m^3) per day radioactive liquid waste sewer (RLWS) that terminates at the 340 Building where waste is monitored for radionuclide content, neutralized, mixed and loaded out via rail tank car and transferred to the 200 Area for further treatment and storage.

There are no direct discharges to the Columbia River from any of the above 300 Area liquid waste systems. All systems except the filter backwash are monitored for flow, radionuclides, and certain nonradioactive contaminants.[5]

Approximately 2200 ft^3 (62.3 m^3) of nonradioactive, solid wastes are transported daily from the 300 Area to the Hanford sanitary landfill located 16 miles (25.7 km) northwest of the 300 Area. In addition, approximately 300 ft^3 (8.5 m^3) of radioactive, nontransuranic, solid wastes are transferred from the 300 Area to the 200 Areas daily for disposal at low level burial grounds.

The 300 Area is self-sufficient in regard to water supply. Water can be withdrawn from the Columbia River at a rate of up to 10,000 gpm (37,850 ℓpm) by one of two large river pumps. The potable water is treated by coagulation, filtration and chlorination at a rate up to 6,000 gpm (22,710 ℓpm). An additional tie-in with the City of Richland grid system with 1,500,000 gallons (5.7×10^6 ℓ) of above-ground storage assures that all present and future programmatic needs are met.

The Hanford and 300 Area environs are typical of the semiarid region of southeastern Washington State that is within the rain shadow of the Cascade Mountains. Precipitation is quite low, averaging 6.25 in. (15.6 cm) yearly. The Hanford Site has a sparse covering of natural vegetation; predominant types are sagebrush/cheatgrass communities intermingled with bitterbush.[(5)]

Soil at the construction site is classified as Rupert sand: a brown to grayish-brown, coarse sand that grades to a dark grayish-brown 3 ft (0.9 m) below the surface. Originally, Rupert sand developed under grass, sagebrush, and hopsage in coarse, sandy alluvial pockets that were mantled by windblown sands.[(5)]

Mule deer, cottontail and jack rabbits, raccoons, beaver, muskrat, mink, weasels, porcupines, coyotes, ground squirrels, and pocket mice are the predominant Hanford Site mammals. Only birds, rabbits, and ground squirrels use the 300 Area as their habitat. Mourning doves, Canadian geese, Swainson's hawks, ring-billed California gulls, and Forester's terns are the most common birds in the area. No known endangered species occupy surrounding areas, although the long-billed curlew and burrowing owl (classified as "status undetermined" by the U.S. Fish and Wildlife Service) are seen occasionally.

Aquatic ecosystems present in the Columbia River adjacent to the 300 Area include zooplankton, macrophytes, phytoplankton, benthos, and periphytic communities. Salmon and steelhead are the two most economically important Columbia River fishes.

Unconfined ground water is generally 30 to 45 ft (9.1 to 13.7 m) below the 300 Area and tends to flow north to south and northwest to south-southeast. The perched ground water is slightly contaminated with uranium and nitrate ions due to previous discharges (now discontinued). The use of the soil column as a filtering medium has caused some local subsurface water mounding.[5,6,7]

4. POTENTIAL ENVIRONMENTAL IMPACTS

The potential environmental impacts of transportation of the steam generator, construction and operation of the interim storage facility and the SGEF are presented below. The impacts of both routine operations and accidental upsets are included.

4.1 TRANSPORTATION

The steam generator that is proposed to be shipped to Hanford is being stored in an engineered storage facility at the Surry Power Station site. The external surfaces of the generator have been decontaminated, and all the openings have been welded closed except for four access covers which are gasketted and bolted. The following steps will take place in removing the generator from storage and placing it on the barge:

- Remove generator from storage facility by means of rollers and winch lines.
- Attached shipping cradle and load on trailer.
- Transport generator to barge.
- Load and secure generator to barge.

4.1.1 Radiation Exposure From Routine Operations

The various tasks associated with the preparation and shipping of the steam generator will expose a total of 30 operational personnel to direct radiation. These personnel include 10 each during loading at Surry, barge travel to Hanford, and unloading-land transport at Hanford. The operations will not generate any solid radioactive waste or radioactive effluents. The individual risks associated with the exposures involved in preparing, handling and shipping the generator will be controlled within the limits set forth in 10 CFR Part 20 for occupational exposure and applicable DOE guides. The limits specified in 10 CFR Part 20 control occupational exposures to 1.25 rem per calendar quarter or 5 rem per calendar year to the whole body. In compliance with ALARA concepts Battelle controls exposures to 3 rem/yr.

Since no radioactive effluents will be generated, no exposure will occur to the public from these sources.

As indicated above, the generator will present a source of direct and scattered radiation. The generator will contain about 120 to 180 Ci of radioactivity of which cobalt-60 is the principal contributor to the dose. With this amount of activity, a dose rate of 0.08 mrem/hr is estimated at the nearest site boundary (approximately 200 ft [61.0m]). This exposure rate will only be present while the generator is outside the vault area. The estimated time to load the generator on the shipping cradle and transport it to the barge is at most 5 days. A person standing at the nearest site boundary for the 5-day period (24 hr/day) could receive a dose of 10 mrem compared to 130 mrem received by an average individual from natural background in 1 yr. After the generator is loaded on the barge, the generator will be shielded so that the dose rate will not exceed the allowable limit established by the DOT [see 49 CFR Part 173.393 (j)] for shipping radioactive material under exclusive-use provisions (see Appendix B, page B.2). Allowable radiation limits for exclusive-use vehicles are:

- 1,000 mr/hr at 1 m (3 ft) from the external surface of the cask
- 200 mr/hr at any point on the external surface of the vehicle
- 10 mr/hr at 2 m (6 ft) from the edge of the vehicle
- 2 mr/hr in any normally occupied position in the vehicle.

In order to meet the standard, 10-in-thick, 20-ft-high concrete walls will be located parallel to the long axis of the generator to ensure that the radiation readings are less than 10 mr/hr 6-ft away from the edge of the barge. The generator will also be covered by a tarpaulin. Since the generator will only be covered by a tarpaulin while on the barge, the following analysis is provided to show the potential exposure risks to the public during transport.

The dose to an individual on a bridge as the barge passes underneath is estimated to be 1.4×10^{-7} rem. Assuming a traffic jam on the bridge as the barge passes underneath, it is estimated the population dose would be 2×10^{-5} man rem. This dose is equivalent to 0.0001% of the annual dose received from naturally occurring sources. The population dose calculations utilized models presented in NUREG-0170.[(4)] The calculation assumed the bridge is 60 ft (18 m) above the upper surface of the generator, that the barge is traveling 7 mi/hr (11 km/hr) and that four lanes of traffic are stopped on the bridge with two persons per car or 160 persons exposed. During routine transportation, dose to the public along the route will be negligible, if not nonexistent, because the public on the riverbank are farther from the barge than the people on the bridge described above.

The dose expected to be incurred by the barge crew during transport will be negligible. The barge will be towed 1200 ft behind the tug, except during those brief periods when tows are changed and during the 36-hour trip up the Columbia River.

Depending on the radiation source, terrestrial and aquatic biota may receive doses about the same or somewhat higher than man receives. Although guidelines have not been established for acceptance limits for radiation exposure to species other than man, it is generally agreed that the limits established for humans are also conservative for other species. Although the existence of extremely radiosensitive biota is possible, no biota have yet been discovered that show a sensitivity (in terms of increased morbidity or mortality) to radiation exposure at the exposure levels predicted for the transshipment. Furthermore, for other operations and facilities for which an analysis of radiation exposure to biota other than man has been made, there have been no cases of exposures that can be considered significant in terms of harm to the species or that approach the exposure limits of 10 CFR Part 20 to members of the public. The BEIR Report[(8)] concludes that the evidence indicates that no other living organisms have been identified that are significantly more radiosensitive than man. Thus, no measurable radiological impact on populations of biota is expected from direct radiation from the transshipment of the steam generator.

4.1.2 Radiation Exposure From Postulated Accidents

The possible accidents that could occur during loading, unloading, shore transport and water transport are: tipping the generator over, dropping the generator, and having a runaway transporter. In addition, other possible accidents are considered, which include sinking, fire and sabotage.

4.1.2.1 Accidents Occurring During Loading-Unloading and Onshore Transport

Several accident scenarios have been evaluated for loading and unloading operations and onshore transport. The analyses of these accidents are present below, along with an assessment of the risks and the precautions taken to prevent mishap.

Tipping the generator over would be highly unlikely because of the relatively excessive accelerations and tipping angles necessary to topple the generator over on its side. The handling operations where tipping forces could be encountered are during removal of the generator from the storage vault and during transport to and from the barge.

The generator will be brought out sideways on rollers from the storage vault by using winches, blocks and cables. The winch cables will be taken up on a drumhead that is driven by a diesel engine. The rotation velocity of the drumhead can be controlled to limit the cable speed. Even under conditions of maximum drum speed or a broken or jerked cable, the acceleration necessary to start the generator tipping (28 ft/sec^2 [8.5 m/sec^2]) could not be achieved.

The tipping forces encountered during transport could be:

- excess side-to-side slope of the haul road;
- transporter tire or frame failure; or
- too high a velocity of the transporter when turning on a curve.

The side-to-side slope of the road to be used to transport the generator to the dock has been reviewed. Results show that the slope needed to overturn the semitrailer is far in excess of the measured road slope. The 13-axle, 104-wheel trailer to be used will be transporting a load about 67% of its rated capacity. Because the load is far below the trailer's rated capacity, the probability of structural failure is extremely small. The most credible failure would be tire failure. If all tires on one side of the trailer failed, the listing angle would not be great enough to tip the generator.

In transporting the generator from the storage facility to the dock area by way of the service road, the shortest turning radius encountered would be about 36 ft (11 m). In order to topple the generator going around a curve of this radius, the trailer would have to be traveling at 20 miles/hr (32 km/hr). For the trailer to make a turn, the wheels have to be turned by a man operating hydraulic controls on the back of the trailer. The operator walks behind the trailer, making the maximum travel speed no more than 2 to 3 miles/hr (3.2 to 4.8 km/hr).

The road that will be used to transport the generator to the dock is within the Surry site boundary and not open for public use, thus minimizing accident potential. There is only one downgrade to negotiate that is between 2 to 3% and about 100 ft (30.5 m) long. At the bottom of the grade the road turns left to the dock site. The road to the dock is parallel to a berm and ditch. A runaway tractor and trailer would be highly unlikely since the trailer has 104 wheels, each with its own set of brakes. The brake system on the trailer is independent of the tractor. In addition, the brake capacity of the trailer is sufficient to stop both the tractor and the trailer in the event of a brake and/or transmission failure of the tractor. Even if the tractor transmission failed and the brakes failed on both the tractor and trailer, the maximum speed the trailer would be traveling by the time it reached the bottom of the grade would be about 10 mph. At that speed the tractor-trailer assembly would come to rest in front of the berm, or at worst, the tractor would drop into the ditch without any damage to the generator. To protect further against a runaway transport system, a guard tractor will be used. In the event any of the above situations occur, it is anticipated the loading of the generator on the barge would be delayed for 2-3 days. The integrity of the generator shell itself would not be breached. There would, however, be an increase in occupational exposure due to recovery operations. The additional exposure incurred will be no greater than the exposure incurred during the normal loading operations. The increased exposure to a member of the public standing at nearest approach for 72 hours would be less than 6 mrem.

At the dock site the tractor and trailer will be driven onto the barge. During loading and unloading operations, the barge will be ballasted to set on the river bottom to minimize the potential of tipping. The generator will be jacked up for removal of the trailer after the generator is positioned on the barge. Blocking will be used to prevent dropping the generator any significant distance in the event of jack failure. After the generator has been removed from the trailer, the generator will be tied down to the deck of the barge (see Figure 6). The tie-downs will be adequate to resist detachment when the generator is subjected to a horizontal or vertical load of 1.5 g. The maximum anticipated force due to rolling and pitching of the barge is about 0.8 g.[1]

At the Port of Benton, the generator will be off-loaded by a crawler. During this operation the barge will be ballasted to set on the river bottom. The generator will be jacked up and blocked similar to the procedure that would be used at the Surry site. The lifting height will be approximately 8 ft (2.4 m). If during this lift the generator falls from the maximum lift height and impacts the deck of the barge, the deck could not withstand this impact force and would fail. However, it is anticipated that the generator would not be breached since most of the impact force would be absorbed as the deck failed.

The only grade that will be encountered in moving the generator to the storage site will be at the dock site. The 6% grade is about 300 ft (91.4 m) long. If a runaway incident took place on this grade, the generator would roll back either onto the barge and into the river or directly into the river. No damage severe enough to breach the generator will result from this accident;

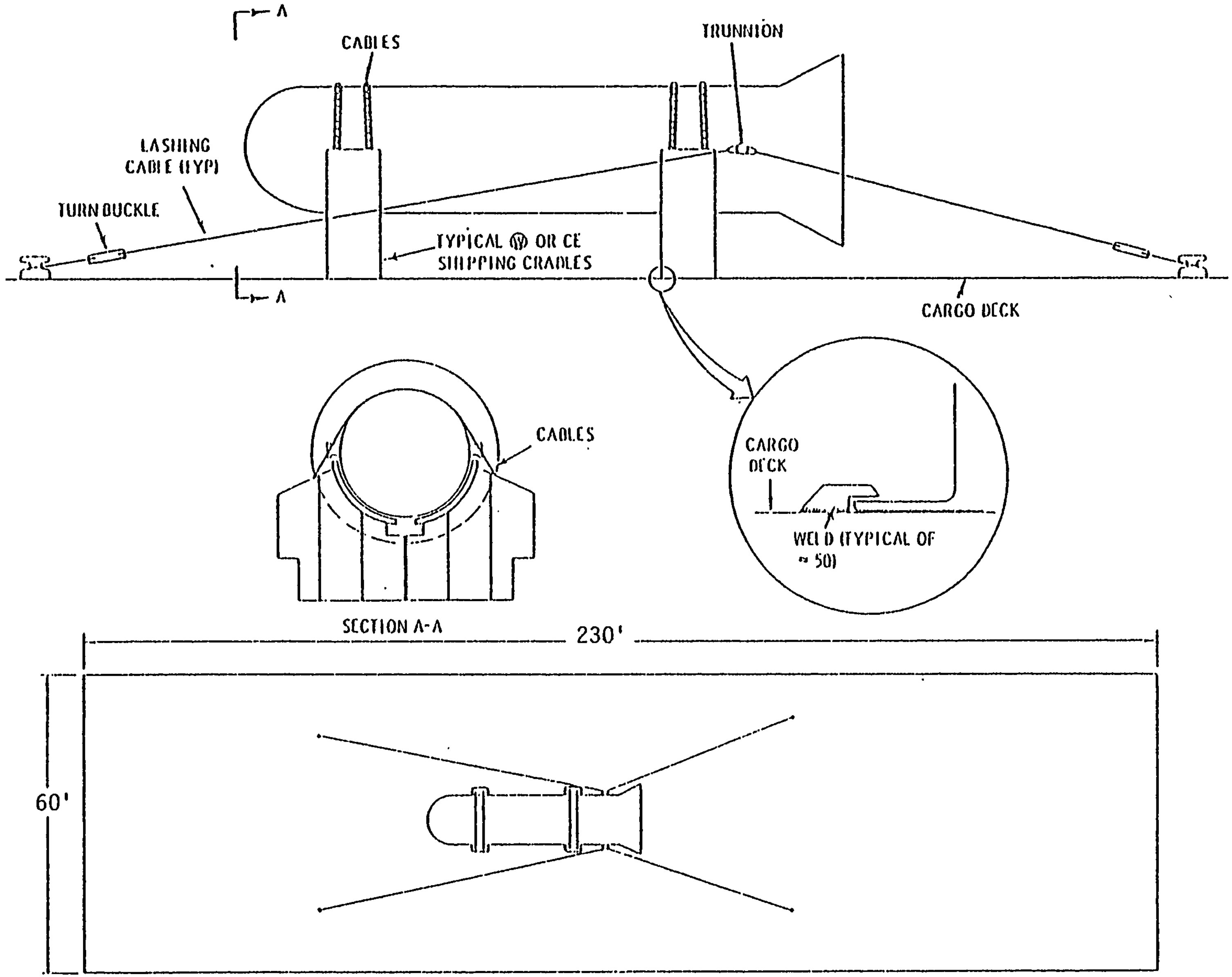


FIGURE 6. Tie-Down Detail Showing Steam Generator Secured to Ocean Barge

therefore, no radioactive material would enter the river; however, 2-3 days would be required to load the generator on another transport vehicle. This operation would result in increased occupational exposures no greater than those experienced during the unloading operation.

The probability of dropping the generator is very small during the lifting operation ($\sim 4 \times 10^{-6}$/operation)[9] to place the generator either on rollers or the trailer. The consequences of a drop during placement on the rollers would be inconsequential because the generator will be blocked and cribbed; in the event of jack failure, the generator would drop only a few inches onto the blocking.

A possible drop could occur when the generator is lifted for placement on the shipping cradles. The generator will be lifted to a height of about 70 in. (178 cm) from the ground level by a sling attached to a header and gantry towers. The sling proper consists of four 2.75-in.-diameter (7.0-cm) steel cables. Conceivably, a sling failure could occur during the lift. This is a remote possibility (1×10^{-6} failures/lift).[10] In addition, the sling will be proof tested before the lift is made. If the generator is dropped 70 in. (178 cm), the shell would fail. However, a shell failure would not necessarily release radioactive material to the environment, since the contamination is integrally bonded to the inner surfaces of the steam generator tubing.

The worst-case accident would involve dropping the generator while it is being placed in the SGEF. Assumptions and models used in analyzing this accident are presented in Appendix A. This operation entails lifting the generator approximately 70 ft (21.3 m) above the ground and lowering it through an opening in the roof of the SGEF. Lifts required for this operation are not unusual at the Hanford site. Dropping the generator from a height of 70 ft (21.3 m) would severely damage the lower end of the generator and could release all the loosened contamination (20% of the inventory). One-tenth of a percent of the released contamination is assumed to become airborne and of a respirable size (NRC Docket 50-280 and 50-281). The resulting 50-yr dose commitment to the nearest, or maximum individual offsite, is estimated to be less than 20 mrem to the total body and 89 mrem to the lungs. The estimated total body dose is approximately 20% of the annual dose due to naturally occurring sources. The individual is assumed to be 150 ft (45.7 m) from the SGEF. The 50-yr dose commitment to the population within 50 miles (80 km) of the SGEF is estimated to be 0.14 man rem to the total body and 0.61 man rem to the lung. The total body dose is approximately 0.000016% of the 50-year dose commitment to the population (171,000 persons) due to naturally occurring sources.

Exposure of the operational work force to airborne radionuclides resulting from this accident is expected to be no greater than the dose to the maximum individual offsite, due to the workers' knowledge of the existence of the airborne release and the response time to evacuate downwind areas. A health physics technician will be present during this operation and workers would be trained in emergency procedures. Exposure to direct radiation would be controlled under emergency response-team criteria and limited by ALARA (as low as reasonably achievable) considerations. In accidents of this magnitude no exposure in excess of applicable limits for routine exposure would be expected. All recovery operations would be performed under the guidance of the Emergency Team Director and would utilize trained and experienced radiation workers with appropriate recovery equipment. As stated above, the probability of this accident occurring is about 10^{-6}.[10]

4.1.2.2 Accidents Occurring During Water Transport

The generator will be positioned horizontally near the center of a 60-ft X 230-ft (18.3-m X 70.1-m) ocean-going barge capable of withstanding severe weather conditions for transport.[1] This positioning will put the nearest surface of the generator some 23 ft (7.0 m) from the edge of the barge with tie-downs as depicted in Figure 6. No credible accident could be identified during river or ocean transport that would breach the generator. Even the collapse of the concrete walls onto the generator would not cause a breach. More probable accidents would be sinking of the barge due to a ramming accident or fire accidents. Accidents involving fire could occur if the barge collided with another ship where flammables could be spilled and ignited. Sinking the generator in the James River would not release any measurable radioactive material in this water system. The generator could sink to a depth of 80 to 90 ft (24.4 to 27.4 m) before the 2-in. (5-cm) cover plate on the end of the generator would fail. The deepest point in the James River along the route the generator will take is about 60 ft (18.3 m). If the generator did sink in the James River no radioactive materials would be released due to the river depth being less than 80 ft.

If the generator is lost at sea and is not recovered, the impact to man can be determined using the method outlined in the PNL-2093 report.[11] The population dose is determined assuming that the generator is breached and all of the radioactive inventory inside the generator is immediately released to the ocean. Such a release is a very conservative assumption since it would take many years to leach the radioactive material from the tubing, and in most situations all the radioactive material would be reduced to low concentrations by the time the material entered the ocean. Releasing all the inventory would produce a total population dose of less than 3×10^{-3} man rem/yr to a population of 3×10^{6} persons or 10^{-8} of the annual dose received by an individual from natural background radiation. The population selected is an estimate of the maximum population that might be affected by this postulated accident based on the highest coastal population density along the route. The most significant pathway to man for the radionuclides released would be through the ingestion of contaminated seafoods.

Once the barge reaches the Columbia River, the deepest portion of river that will be traversed in transit to the Port of Benton will be 2 to 3 miles (3.2 to 4.8 km) above the John Day Dam. The river at this point has been sounded to depths of 191 ft. If the barge were sunk at this point of the river, water would enter the generator. The probability of the barge sinking in the river systems is small. To get some quantitative likelihood for an accident severe enough to sink the barge, data was obtained from the Coast Guard incident records. Using data appearing in Appendix B of the AIF/NESP-014 report[12], the probability of an accident severe enough to sink the barge would be about 3.4×10^{-8} to 6.1×10^{-8} per barge mile (2.1×10^{-8} to 3.8×10^{-8} per barge kilometer). In addition to the extremely small probability of the barge sinking, the consequences of sinking are estimated to be negligible. To determine what kind of impact a release in the Columbia would have on a maximum individual, it was assumed that 20% of the inventory (NRC Docket 50-280 and 50-281) would be released to the river as a continuous discharge over a 4-month period of time. This estimation is considered to be conservative since, if the barge is sunk, immediate recovery action would be undertaken. Planning provisions have already been undertaken to provide for the recovery of the steam generator should sinking occur. Time necessary for recovery in either the James River or Columbia River would be short. A barge and crane capable of lifting the generator is available at both ends of the transport journey. Thus, equipment activation time for river recovery would be minimized. Funding for recovery operations is guaranteed by insurance coverage by the carrier. None of the towns bordering the river below the John Day Dam takes its drinking water from the river. Consequently, the only pathway to man would be through ingestion by fish and irrigated food stuffs and recreational activities such as swimming and boating. The 50-yr dose commitment to a "Maximum individual" would be 4×10^{-3} mrem (see Appendix A.2).

The 50-yr dose commitment to the average individual downstream due to the same accident would be an order of magnitude less than the dose calculated for the maximum individual, which is due to the lower consumption rates of fishes and irrigated crops and lower recreational use rate of the river by the average individual. While few data are actually available concerning the number of persons using the river, it is assumed that all persons living along the Columbia River downstream of the postulated accident site (1×10^6 persons) might be exposed. The population dose to these persons would be approximately 0.4 man rem or 0.0003% of the annual dose from naturally occurring sources. This dose coupled with the probability of the postulated accident occurring would result in a very minor impact to the exposed population.

The dose to recovery personnel who would retrieve the steam generator from the Columbia River, should this accident occur, would be equivalent to the dose received during routine loading and unloading operations.

Contingency plans for credible upset conditions, such as breaking the tow cable, fires, beaching, etc., are presented in Reference 1. In addition, the security/radiation control procedures for protecting the public are addressed in Reference 1. A specific example is the security zone to be established while the barge is docked, when the tug is refueling in the Panama Canal Zone.

4.1.2.3 Accidents Involving Fire

In an accident on the barge involving fire, the generator would remain sealed. The pressure induced from expansion of the air would not cause the generator to fail. No pressure would result from the decomposition of the corrosion product. The active layer containing the radioactive material is quite refractory. The melting point for the $Ni_xFe_yO_4$ compounds would range between 2900 to 3270°F (1600 to 1800°C). The most severe fire environment would produce a temperature of about 1875°F (1024°C), which is below the melting point of the corrosion products. Consequently, no radioactive material would volatilize. Instead, the elevated temperature would promote diffusion between the $Ni_xFe_yO_4$ crud layer and the Inconel tube wall. The diffusion reaction would make the crud layer more adherent to the tube walls. Consequently, accidents involving fire and generator rupture would be no worse than previously presented analyses describing the sinking of the generator and barge.

4.1.2.4 Sabotage

The possibility of sabotage was considered during preparation of the Environmental Assessment. In the unlikely event that an actual sabotage were perpetrated, it is anticipated that impact of sabotage would be no greater than the maximum credible accidents postulated in the accident scenarios.

4.2 CONSTRUCTION

Construction of the interim storage facility will involve minimal environmental impacts. The most significant of these will be the pouring of a concrete pad on which to store the generator. Once the generator is moved to the SGEF, this pad will be the only remaining vestige of the interim storage location.

Resource commitment for the interim storage facility includes:

- plywood 1200 ft^2 (111 m^2)

- concrete 9.6 yd^3 (7.3 m^3)
- reinforcement steel 1200 lbs (544 kg)
- duct work 50 lbs (22.7 kg)
- electrical wiring 400 linear ft (122 m)

The commitment of these resources will have no measurable effect on availability of these materials. It is anticipated all of the materials used for the interim storage facility (except concrete) can be reused.

Local, temporary environmental impacts will occur during the construction stage of the SGEF. Ambient noise levels will be increased, especially during heavy machine operations. The impact upon nonconstruction workers, however, may be noticeable since the nearest occupied buildings (J. A. Jones Construction Company Management Trailers) are 100 ft (30 m) from the proposed construction site. Noise from earth-moving equipment and trucks hauling concrete and building materials to the construction sites is estimated to be 80 to 85 decibels (dBA) at a distance of 50 ft (15.2m) from the equipment.(13) Construction workers and equipment operators will be provided with ear protection. Noise levels will be maintained within limits as specified in the Occupational Safety and Health Act (OSHA).

The environment in the immediate construction area was disturbed during initial construction several years prior to this proposed action. The use of this area for the proposed construction purposes will not affect the quality of the environment. The use of controlled sprinkling during excavation and stabilization of the site after construction will minimize any dust problems. A concerted effort will be made to maintain total suspended particulate matter to less than the Federal air quality standard of 75 $\mu g/m^3$ annual geometric mean(14) at the construction site. It is not anticipated that the air quality standard will be exceeded off the Hanford site.

Land committed for the building site includes less than 1 acre (0.4 hectare) for the building and parking. In relative terms, less than 0.3% of the 300 Area would be committed for the SGEF or less tha 0.0003% of the entire Hanford Site. The construction site will be kept free of construction wastes, which will be picked up daily.

Resource commitments for the new facility include:

- concrete - 440 yd^3 (336.4 m^3)
- reinforcement steel - 31,000 lbs (14,061.6 kg)
- structural and miscellaneous steel - 70,000 lbs (31,752.0 kg)
- piping - 605 linear ft (184.4 m)
- duct work - 13,000 lbs (5,896.8 kg)
- gypsum wall board - 7,700 ft^2 (715.3 m^2)
- electrical wiring - 10,000 linear ft (3,048.0 m)

The commitment of these resources will have no measurable effect on availability of these materials and represents a small fraction of regional uses.

The work force required for SGEF construction should not affect local goods and services industry. Any impact to the business community should be beneficial. It is anticipated the peak period construction work force for this project will be approximately 15 workers. The construction work force currently in the Tri-Cities area is approximately 10,000 workers. The construction work force required for this project will be provided by the current resident work force in the area. Therefore, it is not anticipated that the construction personnel for this project will significantly affect local services, such as water, sewer, or power. A temporary incremental increase in vehicles traveling to the 300 Area will cause additional rush-hour traffic.

4.3 OPERATION

Operations in the interim storage "greenhouse" will be limited to nondestructive testing. There will be no operations involving cutting, burning or welding on the generator. A generator manway will be opened, utilizing "greenhouse" protection, and automatically operated In-Service-Inspection equipment will be inserted. Inspection data will be recorded by electronic equipment located in the "greenhouse". The equipment will require only occasional operational checks by PNL staff. Recording charts removed from the equipment will be analyzed in a facility other than the interim storage "greenouse" in order to minimize occupational exposure. The steam generator is anticipated to be stored at this location for one year. During this one-year period, six months will involve collecting In-Service-Inspection data.

The SGEF will be designed and operated to limit the impact of waste discharges to the environment and the general public to the lowest technically and economically practicable level. In addition, a concerted effort will be made during design, construction, and operation to reduce energy requirements to a minimum, to reduce waste product generation and volume, and to recover and reuse as much waste as possible. Examples of energy conservation include the use of energy-conserving fluorescent light fixtures, weatherproof compounds and administrative temperature controls set to 65°F (18.3°C) maximum in the winter and 80°F (26.7°C) minimum in the summer.

Electrical power requirements for the building will be less than 1% of the total 300 Area power capacity and can be readily handled by a tie-in to the 300 Area system.

Pollution abatement devices and related systems to be designed into the SGEF include the following:

- backflow preventors on all potable water lines to prevent cross contamination;
- a minimum of double HEPA filtration on all radioactive exhausts except the exhaust of the portable "greenhouse" which will have triple HEPA filtration;
- isokinetic sampling of the radioactive exhausts to conform with American National Standards Institute (ANSI) N 13.1-1969[15];
- room air sampling and subsequent analysis in potentially contaminated areas to detect unplanned radionuclide releases.

The exposure of operational personnel to direct radiation will be controlled to within limits contained in applicable DOE standards and guides. Every effort will be expended to maintain exposure as low as reasonably achievable (ALARA).

A Safety Analysis Report (SAR), as required by ERDA Manual Chapter 0531, will be prepared for the SGEF and interim storage prior to operation.

A Safety Analysis Report is a safety document showing, for the nuclear material being processed, that the nuclear facility and its safety related systems with reasonable assurance can be operated without undue risk to the health and safety of the public with adequate provisions for the protection of property and the environment.

4.3.1 Routine Releases

There will be no routine releases from the interim storage location. In the event early, nondestructive testing becomes desirable, an access port will be opened on the generator to insert remote In-Service-Inspection equipment. This portion of the generator will be located in the greenhouse. Because the radioactive material in the generator is bonded to the internal surfaces, opening of an access port should not result in release of airborne radioactive material. However, the greenhouse exhaust will be equipped with single-stage HEPA filtration for added protection.

Routine SGEF operations will generate liquid, gaseous, and solid nonradioactive and radioactive wastes. Discussed here are the environmental impacts of the disposal or storage of these wastes and the impacts upon area systems to treat the wastes.

The facility will generate approximately 10 ft^3 (0.3 m^3) of nonradioactive solid waste per week. This waste, after being compacted to about 20% of its original volume, is not expected to impact upon the land requirements of the Hanford central landfill. The SGEF will cause the 300 Area solid waste receipts at the landfill to increase by less than 0.1%.

Approximately 10 ft^3(0.3 m^3) per month of nontransuranic, low-level, radioactive solids including scrap metal, filters, wipes and miscellaneous paper and cloth will be generated during the operation of the SGEF. This represents an increase of about 0.2% of the nontransuranic 300 Area wastes that are transferred to the 200 Areas.

Nonradioactive toxic liquids and solids will be individually managed through existing Hanford facilities. Rigorous safety, industrial hygiene, and waste management protocols will be followed. In general, toxic liquids will be neutralized, detoxified, immobilized, and incinerated or disposed in an approved chemical disposal trench. Solids will be properly packaged and buried; agents will not be directly released to the environs.

Nonradioactive SGEF liquids released to 300 Area waste management systems include 300 gal (1.1 m^3) per day of sanitary waste. This quantity of liquid will amount to a less than 0.1% increase in the total load on the 300 Area sanitary waste system. No adverse impact is projected as a result of SGEF operations.

The releases of airborne radioactive particulates and gases from SGEF routine operations are expected to be extremely low. Radioactive ventilation systems will be serviced by a double-stage HEPA filter with an efficiency of 99.97% for the first stage and 99.5% for the second. The exhaust from the greenhouse will be filtered by a third stage of HEPA filtration with an efficiency of 99.5%.

Activities at the steam generator facility will include various cutting operations on the steam generator shell and tubes. Torch-cutting operations, through the vaporization of contaminated metal, will release radioactivity to the building filtration system via the greenhouse.

For the purposes of this conservative analysis, it is assumed that all cutting is done using a torch and that 35 tubes and approxmiately 10 ft (3 m) of steam generator shell are cut per week. In the process of cutting, a strip of metal approximately 0.38 in.(0.97 cm) wide[16] is removed and the contamination vaporized into the greenhouse. The resulting daily release to the greenhouse is 1.2 X 10^2 µCi/day. Following filtration through the triple HEPAs (99.97% first stage, 99.5% second and third stage), the release to the environment is 1.1 X 10^{-5} µCi/wk or 5.6 X 10^{-4} µCi/yr. This release results in an annual stack concentration of 3.1 X 10^{-18} µCi/cc, which is approximately 1 X 10^{-6} percent of the applicable ERDA Manual Chapter 0524 Table II limits for air.[15] The maximum individual or population dose commitments were not calculated due to the extremely low stack concentration and the fact that the releases were several orders of magnitude below the ERDA Manual Chapter 0524, A, Table II guides for air. There were no credible accidents identified that could lead to the release of significant quantities of radioactive material to the environment.

4.3.2 Conclusion

There are no known adverse environmental impacts associated with the normal operation of the Steam Generator Tube Integrity program. The release of both radioactive and non-radioactive wastes will be reduced to levels that will produce no detectable effects by the use of pollution abatement systems and the inherent design features of the generator itself. No radiation releases are anticipated during transportation. Radiation releases as a result of routine operations or potential accidental upsets at the interim storage location or routine operation of the SGEF are estimated to be well below ERDA Manual Chapter 0524, Annex A, Table II concentration guides.

Minor localized environmental impacts will occur during the construction of the SGEF: noise pollution, slight air pollution as a result of construction dust, traffic, and a small increase of usage upon area services. However, most of these impacts will be minimized through good engineering practice. No environmental impacts are anticipated from routine project operations. Airborne particulate emissions from the high-bay area of the SGEF will be treated by double-stage HEPA filtration. Airborne emissions from the green house operation in the SGEF will be treated by triple-stage HEPA filtration. Liquid releases will be treated by appropriate 300 Area systems.[5]

Postulated worst-case SGEF accident doses would also be at least seven orders of magnitude less than the applicable standard.[17] No adverse environmental impact is therefore expected.

It should be borne in mind that the radioactive material lodged within the corroded tubing is primarily cobalt 60, a relatively short-live radioactive isotope used in cancer treatment and industrial radiography. There is less than 1/5 gram of cobalt 60 distributed evenly inside the tubing. This is less than about 1/30 the amount of cobalt 60 commonly contained in the cancer treatment irradiators used by many large hospitals.

4.4 SITE RESTORATION

After construction of the SGEF is completed, the site will be restored to a condition as close to its original state as possible. All construction debris will be either recycled or disposed.

Program requests include funds for site restoration once the facility has fulfilled its usefulness.

4.5 FLOOD-PLAIN MANAGEMENT

Because of recurring damage due to flooding, proper flood-plain management has become an item of national concern. This national concern was manifested May 24, 1977, by executive order 11988 entitled Flood-Plain Management as interpreted by 10 CFR 1022. The proposed Steam Generator Examination Facility discussed in this Environmental Assessment is not located in a flood plain as defined by the previously referenced executive order. By definition, a flood plain is any low land or relatively flat area adjoining inland or coastal waters that is flood prone. The base flood plain is subject to a 1% or greater chance of flooding in any given year (the 100-yr flood) while the critical flood plain is subject to a 0.2% or greater chance of flooding in a given year (the 500-yr flood). The 300 Area, where these facilities are to be constructed, is nominally at an elevation of about 400 ft (122 m) with the SGEF at 388 ft (118 m) and the interim storage location at 400 ft. The estimated 100-yr maximum flood of 440,000 cfs (12,460 m^3/sec) would result in a river level of 356 ± 2 ft (108.5 ± 0.6 m) at the 300 Area based on U.S. Corps of Engineers projections. The 300 Area would not be subject to inundation by the 100-yr flood.[18]

Information on the estimated 500-yr maximum flood is not available for the Columbia River near the 300 Area. In its stead, the Probable Maximum Flood (PMF) as evaluated by the U.S. Corps of Engineers for 1975 regulated flow conditions was used.[5,15] The PMF would have a flow of 1.44×10^6 cfs (4.1×10^4 m^3/sec) and would result in a river level of 382 ± 4 ft (116.4 ± 1.2 m) at the 300 Area. Since the elevation of the site of the SGEF is 388 ft (118 m), and the interim storage site is 400 ft (122 m), it is concluded that neither site would be subject to inundation by the PMF and therefore would not be subject to inundation by the 500-yr flood.

5. COORDINATION WITH FEDERAL, STATE, REGIONAL OR LOCAL PLANS

A concerted effort has been and will be made to keep applicable governmental agencies involved with the planning, design, and operation of the SGEF, and to assure compliance with all applicable regulations. No conflicts with federal, state, regional or local agencies are known or anticipated as a result of this action.

6. DECONTAMINATION AND DECOMMISSIONING

Due to the low-level radioactive contamination of the steam generator, provisions to decontaminate the floors and walls of the generator tower will be included in the design of the facility. Decontamination provisions will consist of a washable/strippable coating for the concrete walls and floors and a sump area with capability for pumping contaminated wastes into a tank truck for transport to a designated disposal area.

On completion of the Steam Generator Tube Integrity program, that portion of the generator remaining in the tower portion of the facility will be removed for disposal by burial. The impacts on the Hanford burial grounds from burial of the steam generator will be small. The total volume of solid waste now buried in the 200 Area burial grounds is 7.4×10^6 ft^3 (2.1×10^5 m^3), which contains 3.8×10^6 Ci of mixed fission products. The resulting increases will be less than 0.01% of the total volume now buried at Hanford. The Steam Generator Examination Facility will then be decommissioned. Therefore, the design of building connections, structural systems, etc., will include provisions for ease of decommissioning, dismantling, and disposal of the facility and for returning the project site to its original condition at the project's conclusion. However, should it be economically and programmatically feasible, the building could be cleaned, decontaminated, and modified for future use in lieu of decommissioning, demolition, and disposal. It is anticipated that a small fraction of the facility structure would require burial as radioactive waste if the structure were demolished. However, if the entire SGEF and Interim Storage Facility structures were disposed of as radioactive waste, the impact on existing Federally owned disposal sites at Hanford would be small, i.e., less than 0.01% of the existing waste in storage. Resource commitments are listed on page 28. Furthermore, the volume of waste generated during demolishing of the structure would not overburden the waste storage capacities of any of the alternate sites discussed in Section 7.

7. DESCRIPTION OF ALTERNATIVES

The alternatives to the proposed action are 1) transport the generator by an alternate means, 2) conduct the project at another location, 3) delay the project and 4) cancel the project.

All large equipment (>150 tons) is brought into the Surry site by barge because the local roads are not capable of withstanding such loads and there is no railroad into the site. Thus, the steam generator would have to leave the Surry site by barge, the same way it arrived.

Transshipment from barge to surface travel was evaluated. Surface travel by truck would be impractical, if not impossible, because of the restrictions on hauling heavy loads on public highways. Even if possible, highway transport would result in a larger population dose due to the extra handling associated with transshipment and low speed travel through more populated areas. The diameter of the transition cone of the generator prohibits travel by railroad, because of the dimensions of certain bridges and tunnels. The transition cone could be removed and replaced with a cylinder; however, this too would result in a larger population dose because of the extra handling associated with transshipment, removal and replacement of the transition cone and travel through more populated areas.

Transport by air was not practical because no combination of air and surface carrier that could handle the loads could be identified.

Transport by ship and barge were investigated. As noted above, the steam generator would have to leave the Surry site by barge. Additionally, the trip up the Columbia River would have to be by barge because of the limited size of the locks at Bonneville Dam. Therefore if a ship were to be used, the generator would have to be transshipped in both the James and Columbia River. The extra handling operations would result in additional occupational exposures to the transport personnel. It was concluded that the most pratical choice was to transport the generator by barge. This choice also represents the transport mode with the least exposure to the personnel involved with transport and to the public.

The alternative of sectioning the generator and transporting it in small packages was eliminated because disassembly of the generator would destroy the data that the research program is designed to obtain.

Although Phases I and II of the Steam Generator Tube Integrity (SGTI) program are being conducted by Pacific Northwest Laboratory at Hanford, it was recognized that the construction of a facility and the transportation of the generator to Hanford would be expensive. Therefore, a survey of other potential sites was performed.

The first site examined was Surry Power Station. This site was eliminated because Virginia Electric and Power Company (VEPCO) would not authorize conducting the program at Surry. Even if authorization could be obtained, this alternative would require a significant relocation of personnel and support facilities that would significantly delay the program. Such delays and relocations would more than offset the cost of transporting the generator to another site.

No commercial site with the combination of facilities and staff capable of conducting the program could be identified. The possibility of constructing a new commercial facility was evaluated; however, it was determined that required relocation of personnel and support facilities and complicated facility licensing activities would significantly delay and add to the costs of the program. In order to eliminate delays and costs associated with these considerations, alternative candidate National Laboratories already engaged in nuclear-related research and development and operated by field offices of the DOE were surveyed.

The survey of alternative sites at National Laboratories postulated building the same type of facility at each site or using an existing facility with equivalent safety and emission control systems. Alternative sites reviewed included Oak Ridge, Idaho Falls and Savannah River as shown on Figure 2. The facility would be constructed and/or operated under the criteria set forth in the appropriate ERDA manual chapters. Therefore, the radioactive and nonradioactive impacts to the environment would be substantially the same at any of the sites. The capability to handle radioactive waste generated by normal operation and for decommissioning of the generator and the building at the completion of the program was assessed at each of the laboratories. There was sufficient capacity in each of the laboratory waste management facilities to handle the normal operating waste and decommissioning of generator and building with no impact on current or anticipated programs.

Savannah River Laboratory (SRL), Oak Ridge National Laboratory (ORNL) and the Pacific Northwest Laboratory (PNL) are sited on navigable water ways, and each could be reached by the proposed barge without transshipment. Each site also has adequate barge and unloading facilities. Several routes involving a combination of barge and overland travel were investigated for transport to Idaho National Engineering Laboratory (INEL). The only feasible route identified was travel from Surry, Virginia to Hanford, Washington by barge, unload, remove the transition cone and replace it with a cylinder, and travel overland to the INEL by rail.

The route to SRL would be down the east coast and up the Savannah River to the SRL dock. This is the shortest route and involves passing near only a few population centers. The proposed site for the facility at SRL is about 15 miles from the barge dock. Travel to the site would require travel over about 12 miles of public highway, which would have to be strengthened to accommodate the load. It is estimated that two bridges along the route would also have to be strengthened. These factors make the SRL less attactive.

The route to ORNL would be down the east coast through the Straights of Florida, through the Gulf, and up the Mississippi, Ohio and Tennessee rivers to the ORNL site. The time for travel would be substantially the same as to Hanford; however, the route would be through several highly populated areas. In addition, there is a significant amount of river traffic on the Mississippi and Ohio rivers. These factors make ORNL less attractive.

The routes to PNL and INEL have already been described. The additional overland travel to INEL by rail makes this site less attractive.

The actual barge travel miles to the laboratories by the routes described above are: SRL - 1000 miles; Oak Ridge - 3500 miles; PNL and INEL -

5600 miles. The probability of a maritime barge accident enroute is given in Appendix B as 4.4×10^{-8}/barge mile. Multiplying the distance to be traveled by the probability of an accident gives the following voyage risk probabilities:

To SRL:	4.4×10^{-5}
To ORNL:	1.5×10^{-4}
To PNL - INEL:	2.5×10^{-4}

Clearly, the voyage risk is minor in all cases, even though there are considerable differences in the distances that would be traveled. These voyage risk numbers are believed to be conservative because the shipment is exclusive use (see Appendix B), the majority of the trip is at sea and the voyage will be governed by the operating procedures in Reference 1. Normal commercial barge operations, which are the basis of the accident probability numbers, are centered in more congested inland waterways and are conducted under much less stringent operational procedures. The draft operating procedures received from the proposed carrier were upgraded using data obtained from Coast Guard investigations of barge accidents. It is believed that the procedures in Reference 1 are the most comprehensive in the tug-barge industry. In addition, contingency procedures for credible upset conditions are included. The procedures cover acts such as recovering the barge and re-establishing the tow in the event of a failure of the tow cable.

The difference in the potential environmental impact of transporting the generator, including potential accidents, and operating the SGEF at any of the National Laboratory sites considered do not provide a clear basis of choice. As a result, an economic evaluation was performed to determine where the program could be conducted at the least cost to the government. The study concluded that the most cost-effective location for the SGEF was the Hanford site and that construction of a new, dedicated facility was also the most cost effective.[2]

Delaying the action would result in an economic hardship if undertaken at a later date. Additional labor and material costs would cause the program costs to inflate considerably. In addition, delaying the project would not substantially alter the potential impact to the environment. Finally, the anticipated early technical benefits to be derived from the project would outweigh any justification for delay. Delaying the shipment until the SGEF was constructed and ready to receive the generator was considered. Delaying the shipment would not substantially alter the potential impacts to the environment during transportation. However, as previously discussed, the three generators from Surry I would be positioned ahead of the desired Surry II generator in the storage facility. This would eliminate access to the Surry II generator. If a steam generator from Surry I could be identified as an acceptable alternate, the delay would result in an economic penalty due to normal escalation and rapidly rising prices for marine diesel fuel. The tug consumes approximately 3000 gallons per day; therefore, a fifty cent increase in fuel costs would result in a financial penalty of about $126,000./ In addition, the preliminary work of characterizing the generator with In-Service-Inspection equipment cannot begin until the generator arrives at Hanford, and an additional six months would be added to the research program.

The fourth alternative, not proceeding with the proposed action, would result in the absence of an environmental impact. Such a decision, however, would negate the opportunity to study a steam generator that has failed and would result in the loss of valuable data on causes of steam generator failure. Such a course of action would not be prudent in view of the critical need for rapid progress in important power reactor programs.

REFERENCES

1. Steam Generator Tube Integrity Program Operational Plan, Battelle, Pacific Northwest Laboratory, December, 1979.

2. Letter from V. P. Fitzpatrick to Bob Clark entitled "Updated Alternate Site Analysis," May 21, 1979.

3. Functional Design for the Steam Generator Examination Facility, Battelle, Pacific Northwest Laboratory, Richland, WA 99352.

4. U.S. Nuclear Regulatory Commission, Final Environmental Statement on the Transport of Radioactive Materials by Air and Other Modes, NUREG-0170, December 1977.

5. U.S. Department of Energy, Final Environmental Impact Statement - Waste Management Operations - Hanford Reservation, ERDA-1538, U.S. Department of Energy, Richland, WA 99352, December 1975.

6. D. A. Myers, Environmental Monitoring Report on the Status of Ground Water Beneath the Hanford Site, January-December, 1977, PNL-2624, Pacific Northwest Laboratory, Richland, WA 99352, April 1978.

7. J. R. Houston, P. J. Blumer, Environmental Status of the Hanford Site for CY-1977, PNL-2614, Pacific Northwest Laboratory, Richland, WA 99352, April 1978.

8. The Effects on Populations of Exposure to Low Levels of Ionizing Radiation, BEIR, National Academy of Sciences, National Research Council, November 1972.

9. J. G. Meltin, R. B. Maxwell, Reliability and Maintainability Manual Process Systems, AECL-4607, January 1974.

10. Report on Survey of Incidents of Personal Injury and Property Damage Accidents Involved in the Operation of Overhead Traveling Cranes. National Safety Council, September 1964.

11. S. W. Heaberline, Consequences of Postulated Losses of LWR Spent Fuel and Plutonium Shipping Packages at Sea, PNL-2093, Pacific Northwest Laboratory, Richland, WA 99352, October 1977.

12. A. J. Unione, A. A. Garcia, R. Stuart, A Generic Assessment of Barge Transportation of Spent Nuclear Fuel, AIE/NESP-014, September 1978.

13. U. S. EPA, Noise from Construction Equipment and Operations, Building and Home Appliances, 1972.

14. "National Primary and Secondary Ambient Air Quality Standards," Federal Regulations, 40 CFR 50, Environmental Protection Agency, July 1978.

15. American National Standards Institute, Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities, ANSI N13.1-1969, American National Standards Institute, New York, NY 10018, February 19, 1969.

16. U. S. Nuclear Regulatory Commission, Radiological Assessment of Steam Generator Removal and Replacement, NUREG/CR-0199, September 1978.

17. U.S. Energy Research & Development Administration Manual, Chapter 0524, "Standards for Radiation Protection," Washington, DC 20555, April 8, 1975.

18. 300 Area Site Description, HEDL-TM5 75-13, Hanford Engineering Development Laboratory.

APPENDIX A

DOSE CALCULATIONS

DOSE CALCULATIONS

TABLE A.1. Documentation of Steam Generator Drop-Accident Dose Calculations

Releases: 2.5×10^{-2} Ci ^{60}Co, 2.5×10^{-3} Ci ^{58}Co, 8.3×10^{-3} Ci ^{54}Mn.

Meteorological Conditions: Moderately stable.

Dispersion Model: Gaussian, Hanford parameters.

χ/Q: Maximum individual 2.0×10^{-2} sec/m^3 @50m

80 km population, 1.4×10^{-1} person · sec/m^3

Release Heights: Ground level.

Computer Code: DACRIN, Rev. 3-31-78.

- Calculated Dose: Acute inhalation, maximum individual and 80-km population, 50-yr dose commitment.
- Files Addressed: Organ data library, Rev. 10-24-78; THERMA, Rev. 10-29-75.

Computer Code: GRONK, Rev. 7-23-79.

- Calculated Dose: Acute air submersion, maximum individual and 80-km population, 50-yr dose commitment.
- Files Addressed: GIN, Rev. 4-24-79.

Release Assumptions:

- 20% of internal contamination is loose.
- 0.1% becomes airborne.

Dispersion Calculation: Dispersion into the atmosphere was calculated using the equations described in Section III B.1.1 of ERDA-1538, Hanford Waste Management Operations Environmental Impact Statement. Crosswind standard deviations, σy and σz, were calculated using the Hanford model.

TABLE A.2. Documentation of Steam Generator River Drop-Accident Dose Calculations

Releases: 2.5×10^{1} Ci ^{60}Co, 2.5×10^{0} Ci ^{58}Co, 8.3×10^{0} Ci ^{54}Mn.

River Flow: 117,000 cfs

Mixing Ratio: 1

Reconcentration Formula: 3

Shore Width Factor: .2

Release Period: 4 mo

Computer Code: FOOD, Rev. 8-1-78

- Calculated Dose: Chronic ingestion and ground contamination, 50-yr dose commitment, maximum individual.
- Files Addressed: Radionuclide library, Rev. 3-15-78
  Food transfer factor library, Rev. 2-27-78
  Organ data library, Rev. 8-10-79
  Ground dose factor library, Rev. 3-15-78

Computer Code: ARRRG, Rev. 8-1-78

- Calculated Dose: Chronic ingestion and river exposure, 50-yr dose commitment, maximum individual.
- Files Addressed: Radionuclide library, Rev. 3-15-78
  Organ data library, Rev. 8-10-79
  Hanford specific bioaccum. factor library
  External dose factor library, Rev. 3-15-78

APPENDIX B

APPLICATION FOR EXEMPTION TO SHIP A PWR STEAM GENERATOR AS A RADIOACTIVE MATERIAL, LOW-SPECIFIC ACTIVITY PACKAGE

APPLICATION FOR EXEMPTION TO SHIP A PWR STEAM GENERATOR AS A RADIOACTIVE MATERIAL, LOW SPECIFIC ACTIVITY PACKAGE

(1) To: OFFICE OF HAZARDOUS MATERIALS REGULATIONS
U.S. DEPARTMENT OF TRANSPORTATION
ATTN: EXEMPTIONS BRANCH
WASHINGTON, DC 20590

(2) A one-time only exemption is being sought to ship a Pressurized Water Reactor steam generator as a radioactive, Low Specific Activity, N.O.S. package, rather than a radioactive material, N.O.S. package. In order that this might be accomplished, an exemption is being sought to raise the limit specified in Code of Federal Regulations, Title 49, Part 173.392 (d)(1)(IV) from 0.001 millicuries per square centimeter (Group II - VI radionuclides) to 0.003 millicuries per square centimeter.

(3) Applicant: JOHN M. TAYLOR
BATTELLE MEMORIAL INSTITUTE
PACIFIC NORTHWEST LABORATORY
RICHLAND, WA 99352 PHONE: 509-375-2811

(4) Background: The Nuclear Regulatory Commission has requested that Pacific Northwest Laboratory (PNL), operated for the Department of Energy by Battelle Memorial Institute, conduct safety research studies on a full scale Pressurized Water Reactor (PWR) steam generator. In order for these studies to be made, it will be necessary to move the generator from the Surry Reactor site at Surry, Virginia, to the Hanford Reservation, Richland, Washington.

Since the steam generator contains radioactive material, it will have to be shipped in compliance with the Code of Federal Regulations, Title 49.

The part of the steam generator assembly to be moved to Richland is the bottom two-thirds of the assembly, shown in Figure 1. After the cut is made, a two-inch steel shielding cap will enclose the open end of the generator. Essentially, all of the radioactive material is contained in the tubing inside the shell, which is shown in Figure 2. The tube bundle consists of 3388 tubes. The radioactive material, associated with the tubing, is contained in a thin layer on the inside walls of the tubing. Figure 3 is a section of a piece of tubing, removed from a PWR steam generator, that is typical and which shows the active layer. The layer is chemically bonded to the tubing and could only be removed by chemically etching or machining or by some other metal removing process.

By the time the steam generator is shipped, the total radioactive inventory will be between 120 to 180 curies, composed mostly of (in decending order) Co-60, MN-54 and Co-58.

The activity is essentially uniformly distributed in the tubing and will be about 0.003 millicuries per square centimeter at time of shipment.

PROPOSAL: Because of the size and weight of the steam generator, it would not be practical to package it in a container that would meet Type B requirements. The generator, itself, will have to serve as it's own containment. We feel that the generator is a strong tight package, since it was designed to withstand pressures up to 3100 psi at temperatures of 650°F. The carbon steel shell wall of the generator is ∿3" thick. Since the radioactive contamination is tightly bound to tubing inside the pressure vessel, it would be, in our judgement, considerably more than three times resistant to release of radioactive material than objects that are contaminated to a level of 0.001 mCi/cm^2 that are only required to be wrapped or enclosed in plastic or wood. The 0.001 mCi/cm^2 contamination limit also refers to objects tht are externally contaminated, whereas, the steam generator will have no external contamination.

As further safety precautions, the generator will be shipped under exclusive use provisions on an ocean-going barge. The barge will be standard flat-deck barge, and the generator will be located slightly aft of midships as shown in Figure 4. Ten inch thick concrete walls will be located parallel to the long axis of the generator to insure that the radiation readings are less than 10 mR six feet away from the side of the barge. The generator will also be covered by a tarpaulin. The generator will be lashed to the barge to meet the 1.5 g loading suggested in the proposed ANSI standard N552.

(5) Chemical Name: None

Common Name: Radioactive Material, N.O.S.

Quantity: Between 120 to 180 curies

Properties and Characteristics: the radioactive material is made up of ^{60}Co (68%), ^{54}Mn (24%), and ^{58}Co (8%). The radioactive material is an oxide that is chemically combined with the corrosive product film. The film is a nickel ferrite ($Ni_x Fe_y O_4$) and the radioactive material is about 1% by weight of the corrosion product film and chemically bonded and keyed to the inner tube wall.

(6) Since this is a first of a kind shipment, where a contaminated generator is being shipped, there is no direct shipping and accident experience. However, similar type shipments, involving reactor pressure vessels and steam generators that were not contaminated, have been made to the Hanford Reservation for completion of the Fast Flux Test Facility and the Washington Public Supply System Reactors 2 and 4. These vessels were fabricated by Combustion Engineering, transported down the Mississippi River, through the Gulf, the Panama Canal, and up the west coast to Longview, Washington, on the Columbia River. At Longview, they were off-loaded onto a river barge, transported up the Columbia River to the Port of Benton, and transported overland by crawler to the reactor site. All eleven (11) of these trips were without accident or incident.

Barge transport of the initial and the replacement generators, as well as other heavy equipment to the Surry Reactor site, has been done as required. In June of 1979, the replacement steam generators (4) were transported by barge from Tampa, Florida, to the Surry site via the James River. This is the second time such an operation has been executed without accident or incident, involving a total of six barge shipments. Similar operations have been carried out for other reactor sites located along coast lines and/or navigable waterways, such as Turkey Point in Florida, and Trojan in Oregon, again without accident or incident.

(7) The proposed mode of transport for the generator is by a flat deck ocean barge, with a dedicated tow vessel. The generator will be shipped under exclusive use conditions, as explained in (4).

We anticipate no increased risks to the public or environment if the exemption is granted. Estimates made by the Virginia Electric Power Co. and the Nuclear Regulatory Commission (Docket-50-280) show that less than one-tenth of one percent of the total radioactive inventory is available for release under catastrophic accident conditions. The postulated accident was a 20-foot drop with a cleavage type failure, creating a leak path on the primary side of the generator to the environment. Based on a total inventory of 180 curies, this would mean less than 0.18 curies would be available for release to the environment. The chance of an accident occurring, of the magnitude necessary to breach the generator (such as in the case of the 20-foot drop) aboard a barge, would be very small. To get some quantitative number for the occurrence of this type of accident, data can be obtained from the Coast Guard incident records. Using data appearing in Appendix B of AIE/NESP-014 report,[1] the probability of accident severe enough to breach the generator would be about 3.4×10^{-8} to 6.1×10^{-8}/barge mile.

Dropping the generator into the James River or Columbia River would not release any measurable radioactive material to these water systems. Immediate recovery of the generator would be instituted if the generator was lost in either river. In the event the generator is lost at sea, the impact to man can be determined using the method outlined in the PNL-2093 report.[2] The population dose can be determined if it is assumed that the generator is breached and all of the radioactive inventory inside the generator is released to the ocean. This, of course, is a very conservative assumption since it would take many years to leach the radioactive material from the tubing and in most situations, all the radioactive material would be decayed away by the time the material got into the ocean. Releasing all the inventory would produce a total population dose of less than 3×10^{-3} man-rem/yr. which is 10^{-8} times below the annual dose received by an individual from average natural background radiation. The probability of an accident occurring where the barge would be lost at sea, would be about 4.4×10^{-8}/barge mile.[1]

---

(1) Unione, A. J., A. A. Garcia, R. Stuart, A Generic Assessment of Barge Transportation of Spent Nuclear Fuel, AIF/NESP-014, September 1978.

(2) Heaberlin, S. W., Consequences of Postulated Losses of LWR Spent Fuel and Plutonium Shipping Packages at Sea, PNL-2093, Pacific Northwest Laboratory, Richland, Washington, October 1977.

Adequate control measures are being taken to reduce risks as much as possible. All activities such as transfer to the barge, cradling and tie down, and off-loading, will be done by approved procedures. The procedure and any supporting design, drawings, etc., will be stamped by a registered professional engineer.

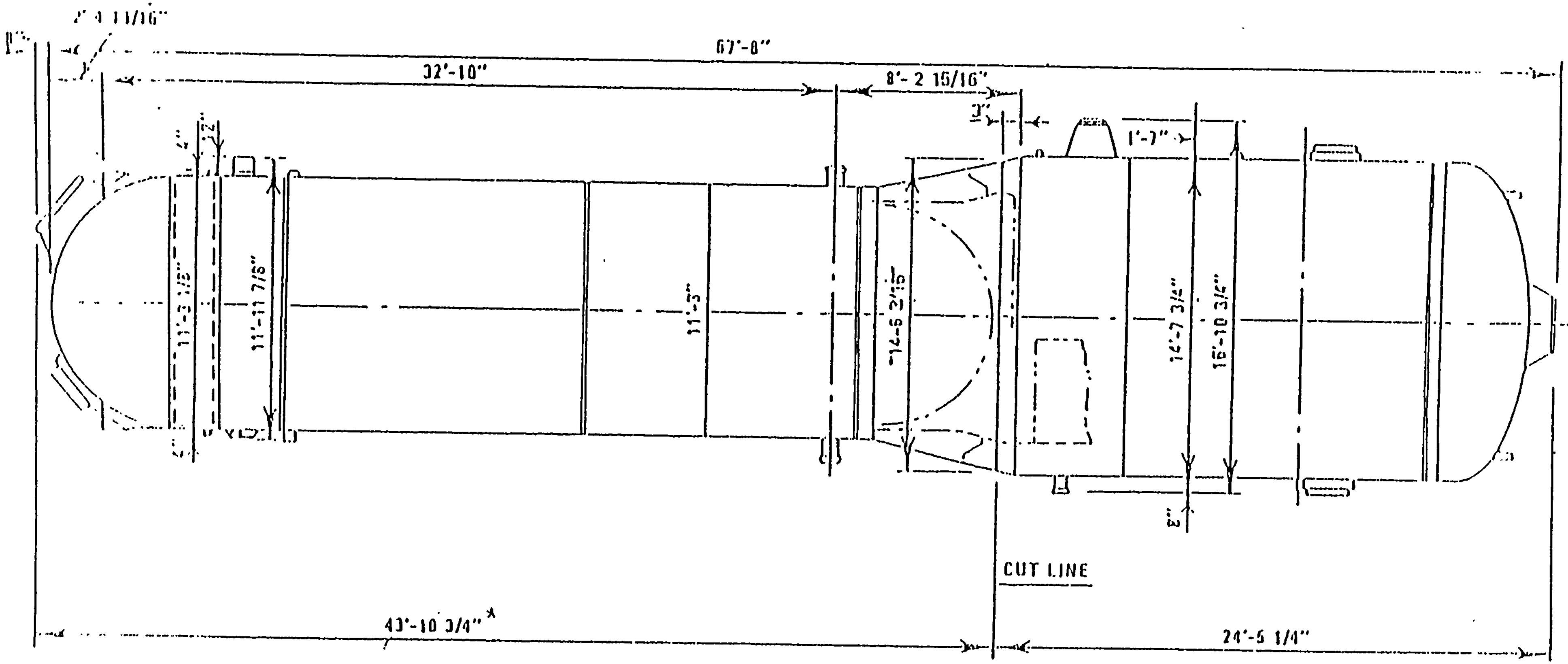
The shipping plan for the carrier will identify the proposed route plus contingency plans and procedures to meet anticipated accident conditions such as failure of tow tackle, etc. Pacific Northwest Laboratory (PNL) will supply continuous Health Physics coverage from the dock at Surry to the dock at the Port of Benton.

(8) Current plans are to ship the generator in March 1980. The route chosen would be down the James River to the coast, follow the coast past Florida, through the Windward Passage, and the Caribbean. Then through the Panama Canal and up the west coast to the Columbia River. The time it will take to get to the Columbia River is estimated to be 45 days. The generator will be brought up the Columbia River to the Port of Benton at Richland, Washington. At the Port of Benton, the generator would be off-loaded by crawler and transported overland about one mile to the Hanford Reservation. The road that will be used to transport the generator from the Port of Benton to the Hanford reservation is controlled by the Department of Energy. The generator will be transported on a weekend and the road will not be open to the public use.

(9) We feel the shipment of the steam generator as a Radioactive Material, Low Specific Activity package, is justified because of the following reasons:

- The radioactive material is uniformly distributed (0.003 mCi/cm^2) and tightly bonded inside tubing which is over 40 miles in length. The tubing is encased in a steel pressure vessel with a 3" thick wall. The vessel provides significantly more than three times the protection that is required for other types of LSA materials where the activity is 0.001 mCi/cm^2.
- In a catastrophic accident, less than 0.18 Ci would be released to the atmosphere.
- Shipment of non-contaminated steam generators has been made, using barges and the same routing that we propose, without incident.
- Approved procedures, stamped by a licensed professional engineer, will be used for all handling operations involving the generator movement.
- The carrier will be selected, based on past performance and ability to meet anticipated accident and emergency situations.
- Continuous Health Physics coverage will be maintained from the dock at Surry to the dock at the Port of Benton.

10. We feel that this exemption should be processed on a priority basis since the generator is the focal point of a multimillion dollar research and development program. The information gained from the research will ultimately provide more energy to the American public by enabling electric generating stations to operate longer and more efficiently. Delays would obviously effect the availability of the results needed by the electric power institutes. Delays in the shipment also have a significant impact on the program budget due to escalation. Delays would cause shipping and handling costs to increase by $20,000 per month.



*This portion to be shipped.

Shipping weight ~ 250 tons

Figure 1

Steam Generator Detail Showing
Portion that will be Shipped

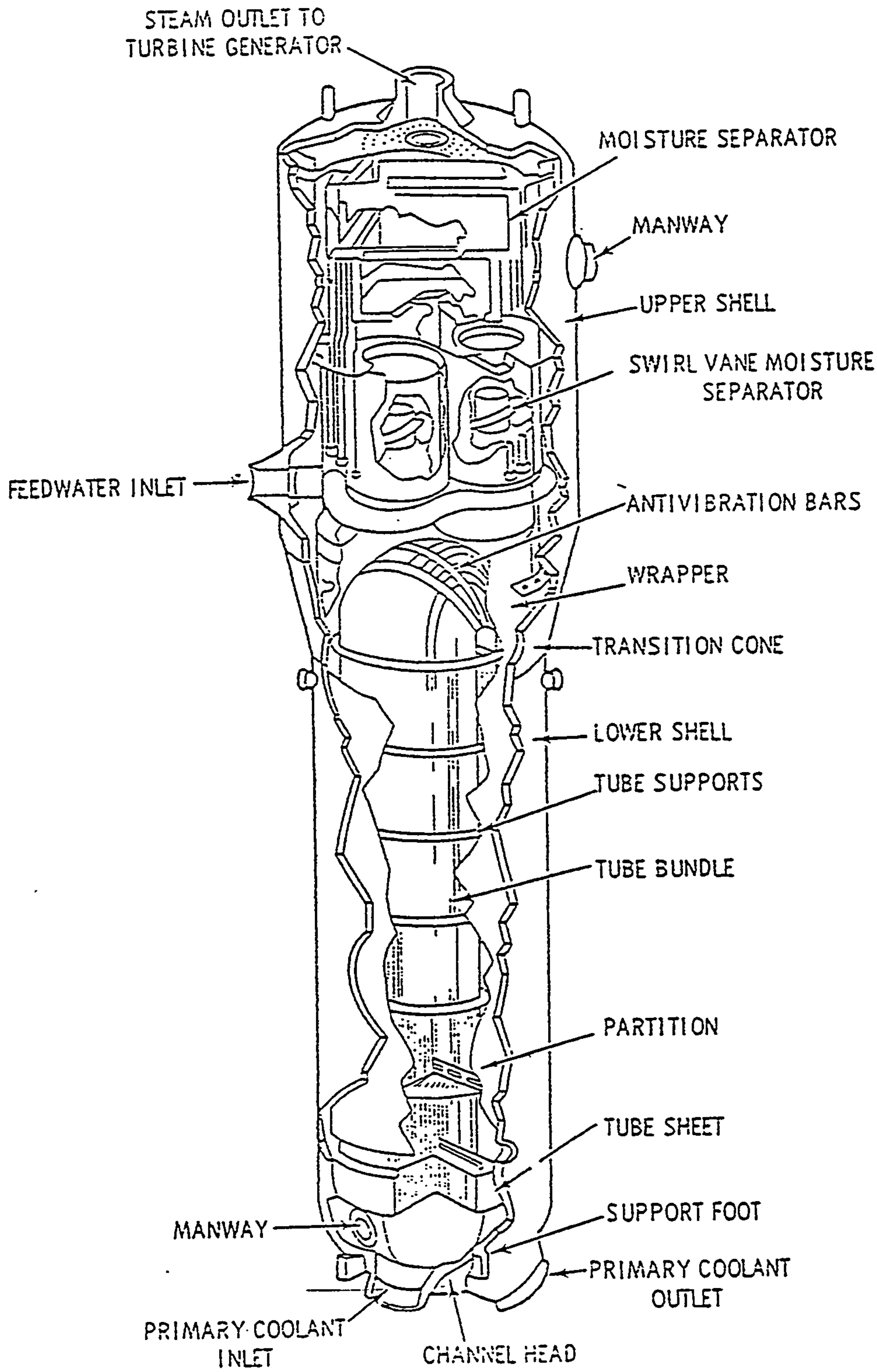


Figure 2

Cut View Showing Internal Detail
of a Steam Generator

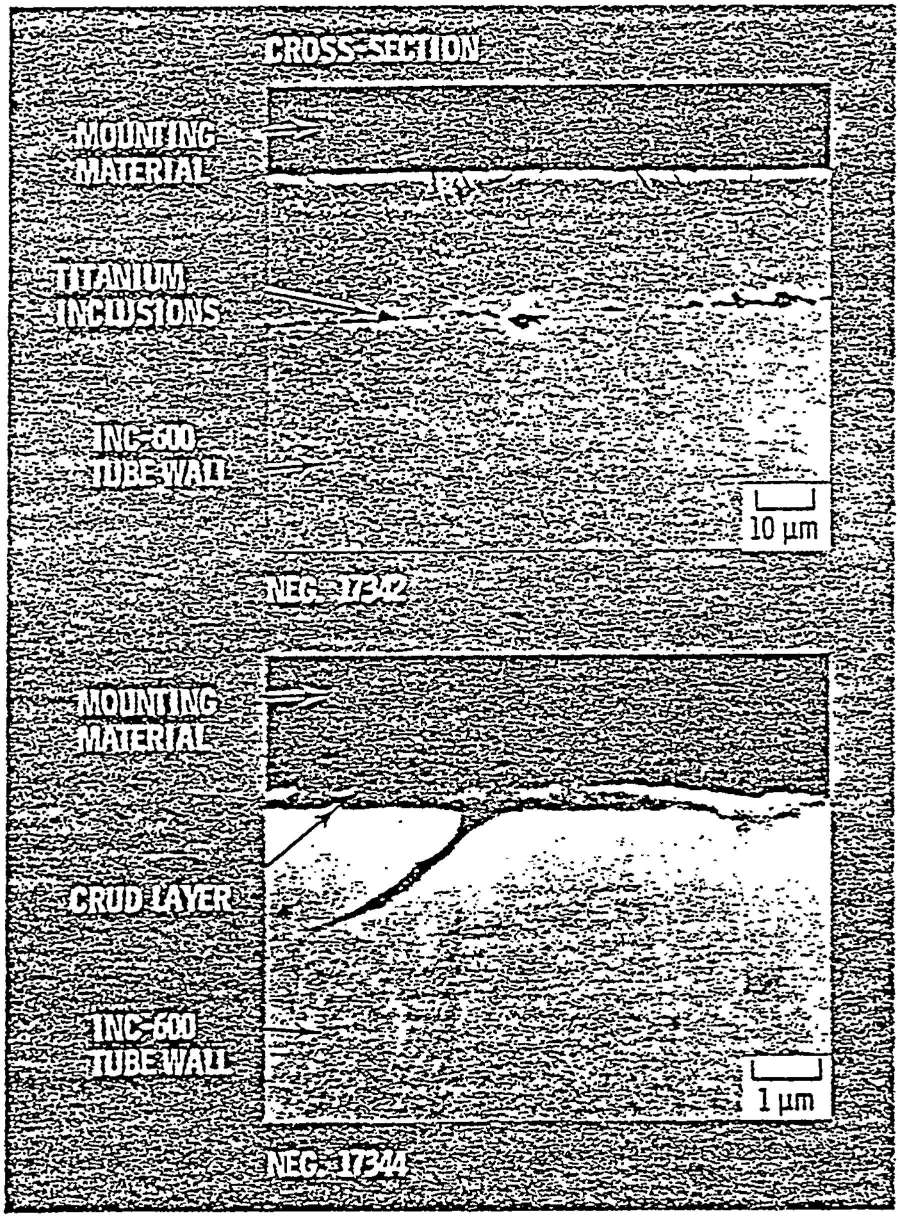
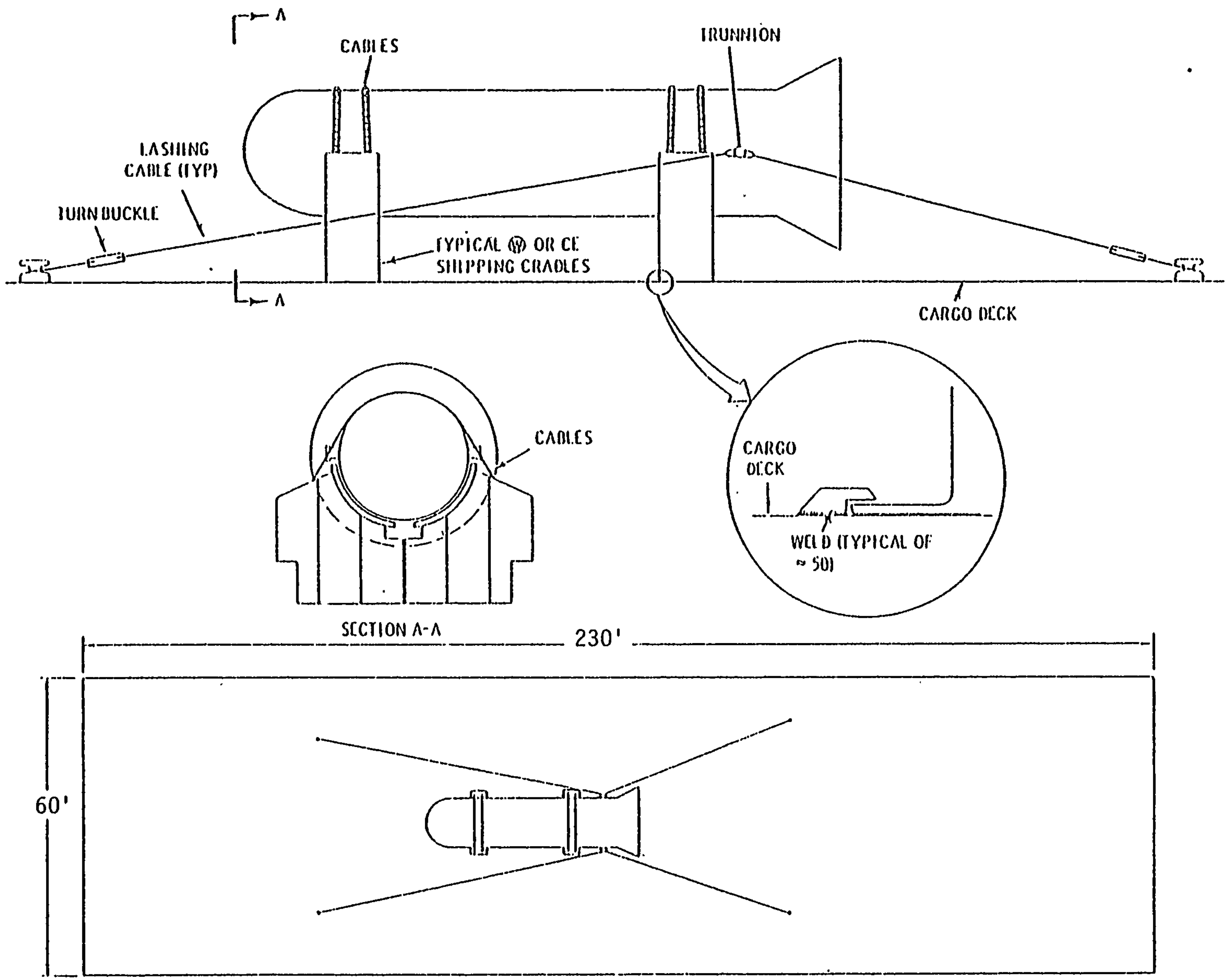


Figure 3

Cross Section of a Typical PWR Steam Generator Tube Showing Corrosion Layer



Tie Down Detail Showing Steam Generator
Secured to Ocean Barge

APPENDIX C

LISTING OF AGENCIES CONTACTED IN THE PREPARATION OF ENVIRONMENTAL ASSESSMENT

LISTING OF AGENCIES CONTACTED IN THE PREPARATION OF ENVIRONMENTAL ASSESSMENT

U.S. Department of Army
Corps of Engineers
Seattle District Office
Flood Plain Management Services
P.O. Box C-3755
Seattle, WA 98124

Virginia Electric & Power Company
P.O. Box 2666
Richmond, VA 23261

Williams Crane and Rigging, Inc.
938 E. Fourth Street
Richmond, VA 23208

Foss Launch & Tug
660 East Ewing
Seattle, WA 98119

Business & Engineering Consultants, Inc.
313 Fairway Drive
Pass Cristian, MS 39571

Lampson Universal Rigging, Inc.
P.O. Box 6388
Kennewick, WA 99336

Tri-Cities Chamber of Commerce
1000 North Colorado
Kennewick, WA 99336